National Defence / Défense nationale

# CHARACTERIZATION OF COLD-WET CONDITIONS (U)

by

Rita M. Crow and Malcolm M. Dewar
*Environmental Protection Section*
*Protective Sciences Division*

**DEFENCE RESEARCH ESTABLISHMENT OTTAWA**
**TECHNICAL NOTE 88-23**

**PCN**
**051LC**

**June 1988**
**Ottawa**

## ABSTRACT

A study was done to determine if cold-wet could be characterized for 12 Canadian centres and Baden-Soellingen, Germany. It was found that, in general, the weather at about 0°C is cloudier and more humid. There is no correlation between temperature and wind or temperature and barometric pressure.



## RÉSUMÉ

Une étude a été effectuée dans le but de déterminer si froid-mouillé pouvait être utilisé pour caractériser 12 centres canadiens et Baden-Soellingen en Allemagne. On a trouvé, qu'en général, pour des températures autour de 0°C, l'ennuagement et le taux d'humidité sont généralement plus élevés. Il n'y a pas de corrélation entre la température et le vent ou entre la température et la pression barométrique.

## INTRODUCTION

A recent literature search (1) found no formal definition of cold-wet climatic conditions, but rather attempts to explain why cold-wet conditions make one feel so cold. None of these were entirely satisfactory or proven experimentally. Further, no standard definition of cold-wet or cold-damp was found. An ABCA standardization agreement (2) describes the principle climatic environments in the world. The one closest to cold-wet is "CO - mild cold" which represents Western European weather conditions. The temperature range is from -6°C for a daytime high to -19°C for a nighttime low. The humidity is at saturation and there is no solar radiation. This is considered to be somewhat cold in Canada and any precipitation would be frozen, and not "wet".

In order to determine whether or not cold-wet can be characterized, weather data for 12 Canadian centres as well as for Baden-Soellingen, Germany were analysed. It was hypothesized that at about 0°C, it will be cloudier and foggier, there will be more precipitation, the humidity will be higher, it will be windier and the barometric pressure will be lower. This paper gives the results of this study.

## METHOD

To test the hypotheses, we obtained from the Canadian Climatic Centre of Environment Canada data correlating frequency of dry bulb temperature between +14.5 and - 14.5°C at 1° intervals with various weather conditions. All the observations were made at hourly intervals between 0800 and 1700 Local Standard Time and, for most of the locations, covered the period from 1953 to 1985. The correlations were given for cloud cover, fog, precipation (liquid, freezing and frozen), relative humidity, wind speed and atmospheric pressure corrected to sea level. This was carried out for 12 Canadian weather stations:- Vancouver, Prince Rupert, Calgary, Winnipeg, Toronto, Ottawa, Quebec City, Saint John, Summerside, St.John's, Iqaluit and Cambridge Bay in Canada and for Baden-Soellingen in West Germany.

Since the number of observations at each temperature were not the same, the number of observations of each condition at a particular temperature was expressed as a percent of the total number of observations at that particular temperature.

It is appreciated that to accurately define cold-wet, all conditions should be recorded simultaneously at a given temperature. This information is not available. Thus, the definition of a cold-wet environment will be proposed to be those conditions which have a high frequency of occurence between ± 14.5°C, although they may not all occur simultaneously.

## RESULTS AND DISCUSSION

The weather data were reduced and the results are given graphically in Annex A. The percentage of time when a particular condition prevails is plotted against temperature. The graphs take several shapes as illustrated in Figure 1. Figure 1a shows no correlation between the condition and temperature. Figures 1b and 1c show correlations between the condition and temperature with a maximum percentage at one temperature and/or a minimum at another. Table 1 gives the temperature(s) at which there is a maximum or minimum percentage. A dash denotes no correlation at all between a condition and temperature.

Calgary has no significant weather conditions around 0°C and so is not included in any further discussions.

It can be seen that at most of the locations, there is no correlation between temperature and wind speed or between temperature and barometric pressures below 102.5 kPa.

All locations have 100% cloud cover 50 to 60% of the time and this cloud cover occurs more frequently at about 0°C at all places except Prince Rupert and Winnipeg.

There is fog about 40% of the time at about 0°C for the inland locations, 60% of the time at St. John's and Baden-Soellingen and 30% of the time at Cambridge Bay. In Vancouver, it is foggy about 50% of the time, but at no particular temperature. Fog occurs more often at or about 0°C at all places except Prince Rupert, Toronto, Iqualuit and, as mentioned, Vancouver.

All the precipation graphs show a correlation with temperature, with the maximum occuring between 30 and 35%. Precipation is at a maximum at or about 0°C at Vancouver, Ottawa, Saint John, Summerside, St. John's, Iqualuit and Germany, but not at Prince Rupert, Winnipeg, Toronto, Québec or Cambridge Bay.

There are high humidities 80% of the time at Prince Rupert, Cambridge Bay, Summerside and Baden-Soellingen, 70% at Vancouver and 50 to 60% at the other locations. The maximum for the 81-100% humidity range is at or about 0°C at all places except Vancouver and Germany. The minimum for the 0-60% humidity range occurs about 0°C at all places except Vancouver and Cambridge Bay.

## CONCLUSIONS

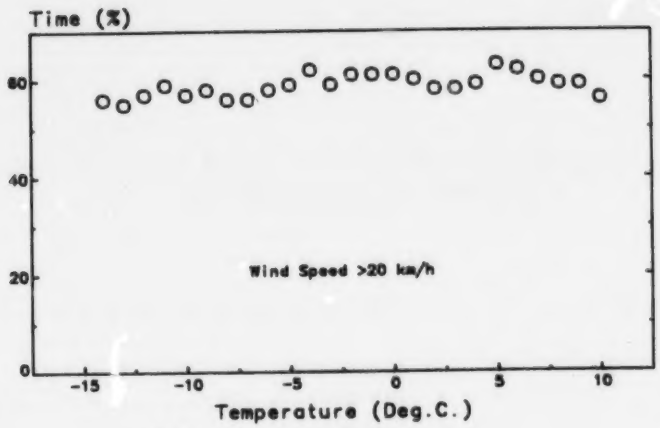
The conditions which occur frequently at about 0°C at eleven of the thirteen locations are 100% cloud and high humidity. Since these conditions prevail over 50% of the time, it can be fairly conclusively stated that they are concurrent. Fog and precipitation occur at about 0°C at nine and eight of the locations respectively. These conditions occur less than 50% of the time and so it is not as likely that they would be concurrent with other weather conditions. At most of the locations, wind and barometric pressure below 102.5 kPa are not related to temperature, especially at about 0°C. Thus the hypotheses that at about 0°C, it would be cloudier and more humid proved to be true. The hypotheses that it would be windier and that the barometric pressure would be lower proved not to be true. The hypotheses that fog and precipation would occur at about 0°C is true for only some of the locations.

It can then be concluded that the cold-wet sensation felt at about 0°C is associated with cloudy and humid conditions, but not with windy conditions or with low barometric pressure.

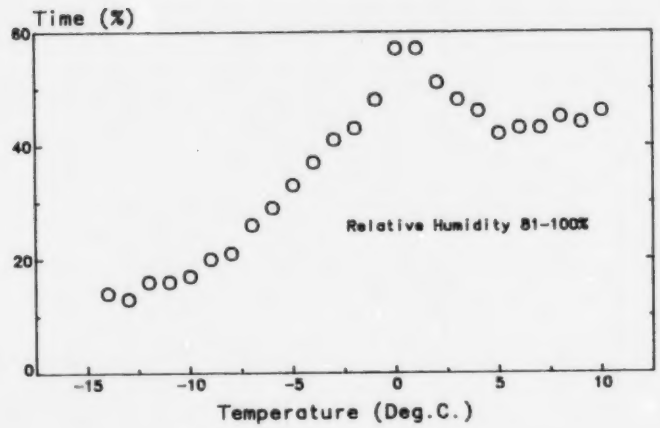
## REFERENCES

1. Rita M. Crow, Why Cold-Wet Makes One Feel Chilled: A Literature Review, DREO Technical Note, In Publication, 1988.

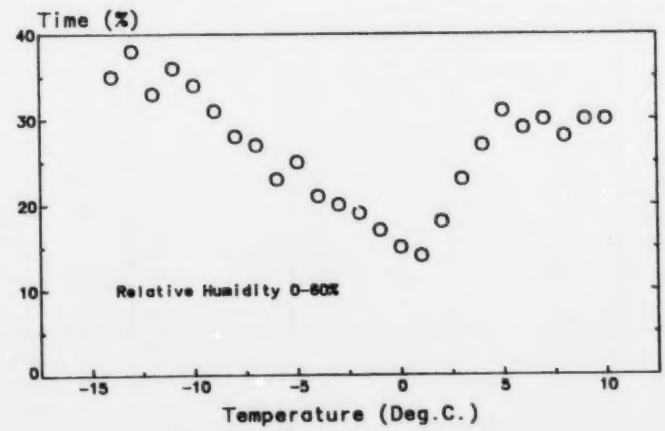
2. American-British-Canadian Australian Armies Standardization Program, Climatic Environmental Conditions Affecting the Design of Military Materiel. Quadripartite Standarization Agreement - 360. December 1979.




(a) No correlation.




(b) Maximum percentage.




(c) Minimum percentage.

Figure 1: Illustrations of the various types of correlations between percentage of times at which each event occurred (Time (%)) and temperature (Temperature (Deg.C.)) for weather conditions.

TABLE 1

Summary of Weather Conditions at which there is a Maximum or Minimum Frequency of Occurence

Temperature at which maximum or mininum occur (°C)

| | Vancouver | | Prince Rupert | | Calgary | | Winnipeg | | Toronto | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| Cloud Cover | | | | | | | | | | |
| 0% | -10 | >0 | -15 | >0 | -15 | - | >-10 | - | -15 | 0 |
| 10-50% | -15 | >0 | -15 | 5 | - | - | - | 0 | -15 | 0 |
| 60-90% | - | - | 2 | -15 | - | - | - | - | - | - |
| 100% | 0 | -15 | 5 | -15 | - | - | -5 | - | 0 | -15 |
| Fog | - | - | - | - | -5 | >3 | 0 | - | - | -5 |
| Precipation | 0 | -11 | 5 | - | -15 | >3 | -10 | >2 | -5 | - |
| Humidity | | | | | | | | | | |
| 0-60% | -10 | 5 | -10 | 0 | >5 | <-5 | 10 | <0 | 10 | <0 |
| 61-80% | -15 | 0 | 8 | 0 | -15 | <5 | - | - | -15 | 10 |
| 81-100% | <-10 | 0 | 0 | -8 | -7 | >3 | <0 | 10 | 0 | - |
| Wind Speed | | | | | | | | | | |
| 0-10 km/h | 0 | - | - | 7 | <-5 | >5 | - | - | - | - |
| 10-20 km/h | - | 0 | -12 | - | - | - | - | - | - | - |
| >20 km/h | 8 | -3 | 7 | 0 | 10 | <-5 | - | - | - | - |
| Pressure | | | | | | | | | | |
| <99.5 kPa | - | - | - | - | - | - | - | - | 3 | - |
| 99.5-100.5 kPa | - | - | - | - | >2 | -15 | <-10 | - | 0 | -15 |
| 100.5-101.5 kPa | - | - | - | - | 10 | -15 | 10 | -15 | >3 | -15 |
| 101.5-102.5 kPa | - | - | 10 | - | - | - | - | - | - | - |
| >102.5 kPa | -15 | 10 | - | 10 | -15 | 10 | -15 | 10 | -15 | >0 |

TABLE 1 (CONT'D)

| | Ottawa | | Québec | | Saint John | | Summerside | | St. John's | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| Cloud Cover | | | | | | | | | | |
| 0% | -15 | 2 | -15 | >-5 | -15 | >0 | -15 | >-5 | -15 | 0 |
| 10-50% | -15 | 0 | -15 | 0 | -15 | >0 | -15 | 0 | -15 | 0 |
| 60-90% | - | - | - | - | - | - | - | 0 | -15 | 0 |
| 100% | 0 | - | 0 | -15 | 0 | -15 | 0 | -15 | 0 | -15 |
| Fog | 0 | -12 | 0 | <-12 | 0 | <-10 | 0 | - | 0 | <-5 |
| Precipation | 0 | - | -7 | - | 0 | - | 0 | -15 | 0 | - |
| Humidity | | | | | | | | | | |
| 0-60% | 10 | 0 | 10 | 0 | -13 | 0 | 10 | <0 | -15 | 0 |
| 61-80% | <-8 | 10 | -15 | 10 | <-7 | >0 | -15 | >0 | <-10 | 0 |
| 81-100% | 0 | -15 | 0 | -15 | 0 | -13 | 0 | -15 | 0 | -15 |
| Wind Speed | | | | | | | | | | |
| 0-10 km/h | - | - | - | - | -12 | - | -15 | - | - | - |
| 10-20 km/h | - | - | - | - | - | - | - | - | 10 | -15 |
| >20 km/h | - | - | - | - | - | - | - | - | - | - |
| Pressure | | | | | | | | | | |
| <99.5 kPa | - | - | - | - | 0 | - | 0 | - | 0 | - |
| 99.5-100.5 kPa | 0 | -15 | 0 | - | - | - | 0 | - | - | - |
| 100.5-101.5 kPa | 3 | -15 | - | - | - | - | - | - | - | - |
| 101.5-102.5 kPa | - | - | - | - | - | - | - | - | - | 10 |
| >102.5 kPa | -15 | >0 | -15 | >-3 | <-8 | >0 | -15 | - | -10 | - |

TABLE 1 (CONT'D)

| | Cambridge Bay | | Iqualuit | | Baden-Soellingen | |
|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | Max | Min |
| Cloud Cover | | | | | | |
| 0% | -15 | >-5 | -12 | - | -15 | >0 |
| 10-50% | 10 | 0 | 10 | 0 | -13 | >0 |
| 60-90% | 10 | - | 10 | - | - | - |
| 100% | -3 | - | 0 | 10 | 0 | -15 |
| Fog | 0 | 10 | - | 10 | <0 | 10 |
| Precipation | -10 | 10 | <2 | 10 | 0 | -15 |
| Humidity | | | | | | |
| 0-60% | 10 | 5 | 10 | <0 | 10 | <0 |
| 61-80% | 10 | <0 | - | 0 | - | 0 |
| 81-100% | <2 | 10 | 0 | 10 | - | 10 |
| Wind Speed | | | | | | |
| 0-10 km/h | - | - | - | -2 | <0 | 8 |
| 10-20 km/h | - | - | +10 | -15 | >2 | - |
| >20 km/h | - | - | <-3 | 10 | 8 | -2 |
| Pressure | | | | | | |
| <99.5 kPa | - | - | - | 10 | - | - |
| 99.5-100.5 kPa | - | - | - | - | >5 | -10 |
| 100.5-101.5 kPa | >5 | - | - | - | 10 | - |
| 101.5-102.5 kPa | - | - | - | - | - | - |
| >102.5 kPa | -15 | >3 | -15 | 10 | <-5 | 10 |

# ANNEX A

## PERCENTAGE OF TIMES AT WHICH EACH EVENT OCCURRED VERSUS TEMPERATURE FOR WEATHER CONDITIONS AT 13 LOCATIONS


Figure A-1 (a) Cloud Cover for Vancouver
(b) Fog and Precipitation for Vancouver
(c) Relative Humidity for Vancouver
(d) Wind Speed for Vancouver
(e) Atmospheric Pressure for Vancouver

Figure A-2 (a) Cloud Cover for Prince Rupert
(b) Fog and Precipitation for Prince Rupert
(c) Relative Humidity for Prince Rupert
(d) Wind Speed for Prince Rupert
(e) Atmospheric Pressure for Prince Rupert

Figure A-3 (a) Cloud Cover for Calgary
(b) Fog and Precipitation for Calgary
(c) Relative Humidity for Calgary
(d) Wind Speed for Calgary
(e) Atmospheric Pressure for Calgary

Figure A-4 (a) Cloud Cover for Winnipeg
(b) Fog and Precipitation for Winnipeg
(c) Relative Humidity for Winnipeg
(d) Wind Speed for Winnipeg
(e) Atmospheric Pressure for Winnipeg

Figure A-5 (a) Cloud Cover for Toronto
(b) Fog and Precipitation for Toronto
(c) Relative Humidity for Toronto
(d) Wind Speed for Toronto
(e) Atmospheric Pressure for Toronto

Figure A-6 (a) Cloud Cover for Ottawa
(b) Fog and Precipitation for Ottawa
(c) Relative Humidity for Ottawa
(d) Wind Speed for Ottawa
(e) Atmospheric Pressure for Ottawa

ANNEX A (CONT'D)


| | | |
|---|---|---|
| Figure A-7 | (a) | Cloud Cover for Québec |
| | (b) | Fog and Precipitation for Québec |
| | (c) | Relative Humidity for Québec |
| | (d) | Wind Speed for Québec |
| | (e) | Atmospheric Pressure for Québec |
| Figure A-8 | (a) | Cloud Cover for Saint John |
| | (b) | Fog and Precipitation for Saint John |
| | (c) | Relative Humidity for Saint John |
| | (d) | Wind Speed for Saint John |
| | (e) | Atmospheric Pressure for Saint John |
| Figure A-9 | (a) | Cloud Cover for Summerside |
| | (b) | Fog and Precipitation for Summerside |
| | (c) | Relative Humidity for Summerside |
| | (d) | Wind Speed for Summerside |
| | (e) | Atmospheric Pressure for Summerside |
| Figure A-10 | (a) | Cloud Cover for St. John's |
| | (b) | Fog and Precipitation St. John's |
| | (c) | Relative Humidity for St. John's |
| | (d) | Wind Speed for St. John's |
| | (e) | Atmospheric Pressure for St. John's |
| Figure A-11 | (a) | Cloud Cover for Cambridge Bay |
| | (b) | Fog and Precipitation for Cambridge Bay |
| | (c) | Relative Humidity for Cambridge Bay |
| | (d) | Wind Speed for Cambridge Bay |
| | (e) | Atmospheric Pressure for Cambridge Bay |
| Figure A-12 | (a) | Cloud Cover for Iqualuit |
| | (b) | Fog and Precipitation for Iqualuit |
| | (c) | Relative Humidity for Iqualuit |
| | (d) | Wind Speed for Iqualuit |
| | (e) | Atmospheric Pressure for Iqualuit |
| Figure A-13 | (a) | Cloud Cover for Baden-Soellingen |
| | (b) | Fog and Precipitation for Baden-Soellingen |
| | (c) | Relative Humidity for Baden-Soellingen |
| | (d) | Wind Speed for Baden-Soellingen |
| | (e) | Atmospheric Pressure for Baden-Soellingen |

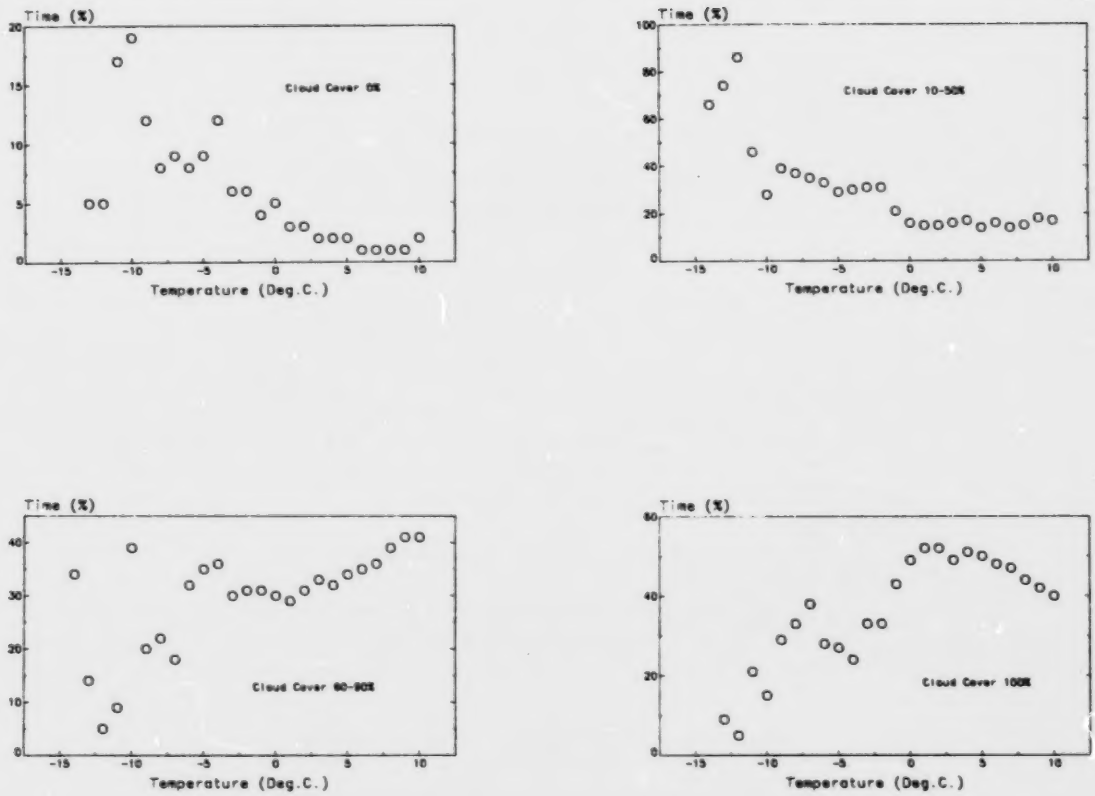



Figure A-1 (a) Cloud Cover for Vancouver

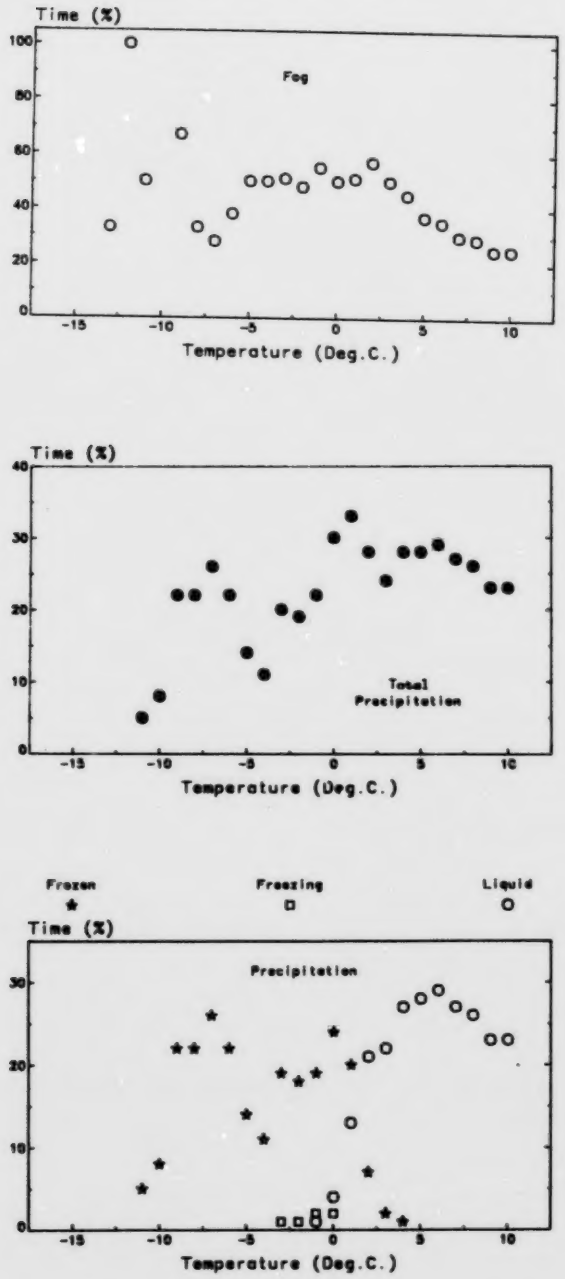



Figure A-1 (b) Fog and Precipitation for Vancouver

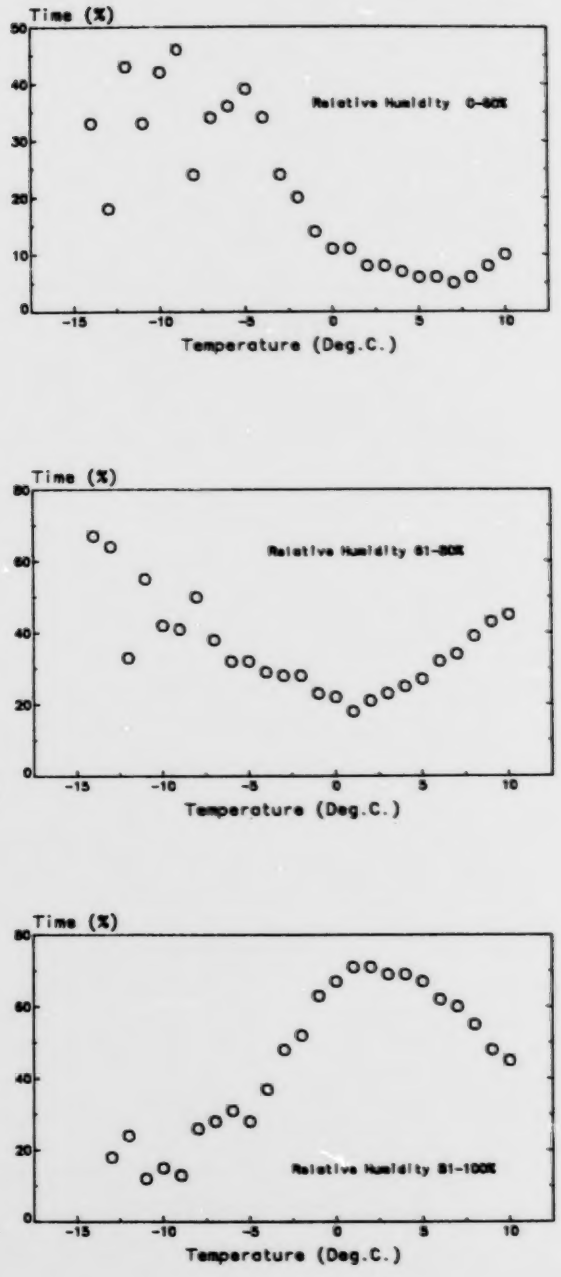
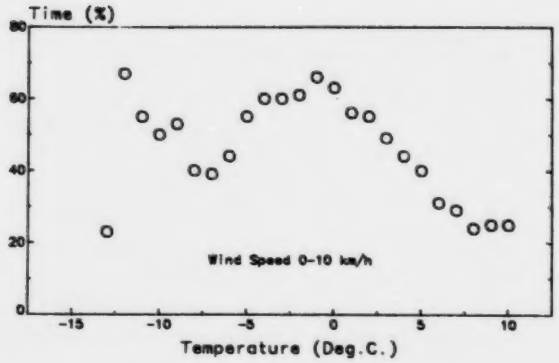
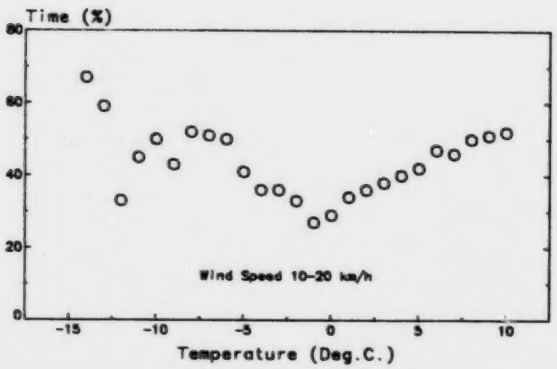



Figure A-1 (c) Relative Humidity for Vancouver



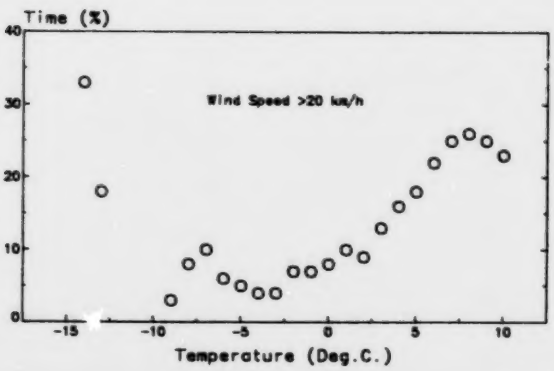
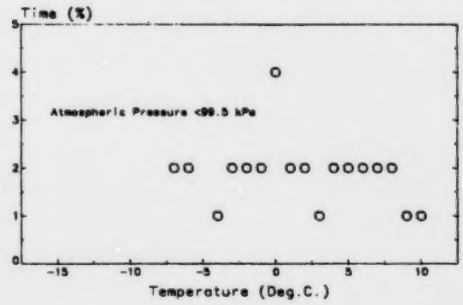
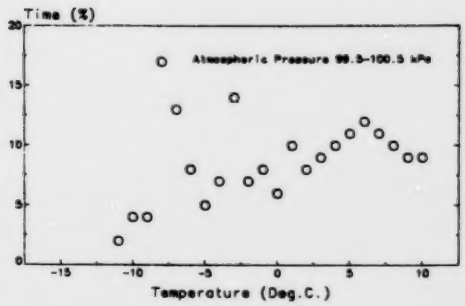
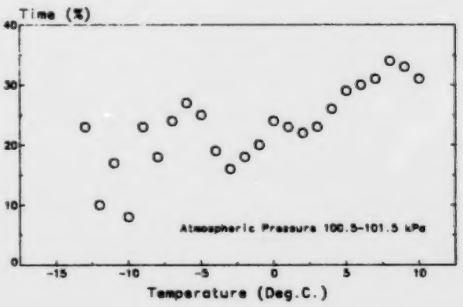
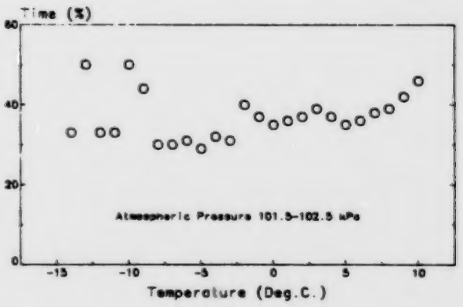




Figure A-1 (d) Wind Speed for Vancouver



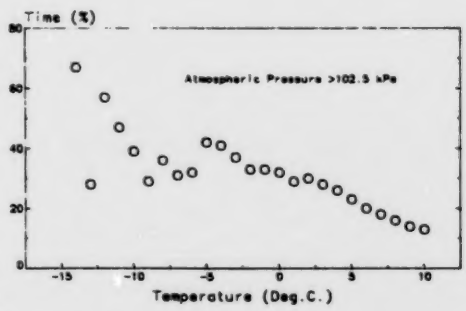




Figure A-1 (e) Atmospheric Pressure for Vancouver

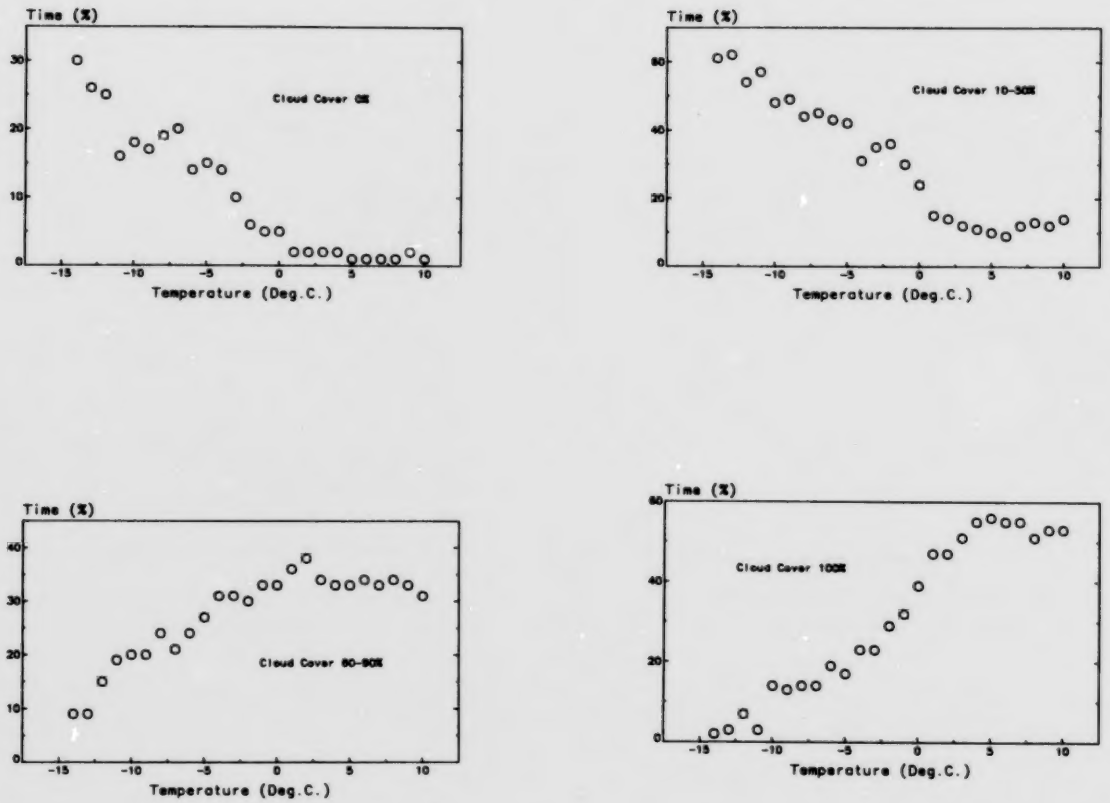



Figure A-2 (a) Cloud Cover for Prince Rupert

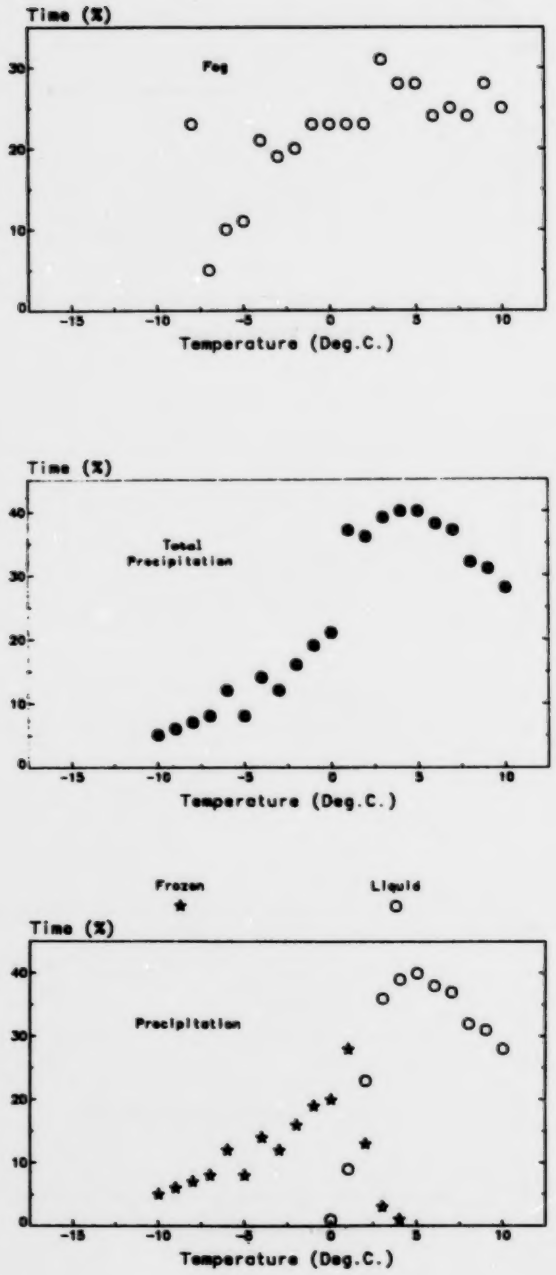



Figure A-2 (b) Fog and Precipitation for Prince Rupert

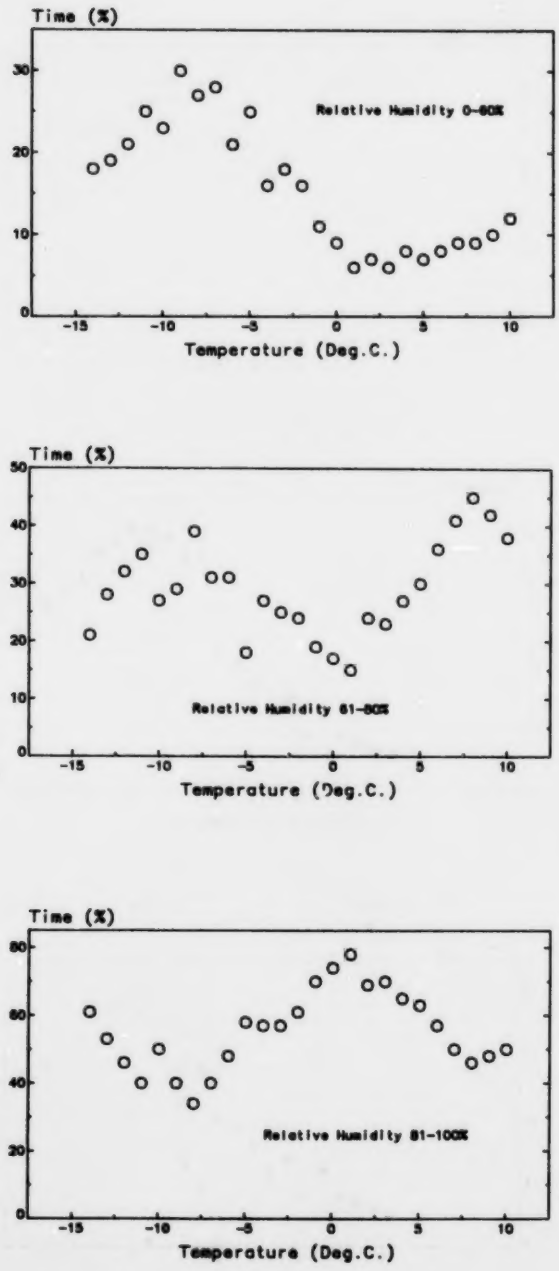



Figure A-2 (c) Relative Humidity for Prince Rupert

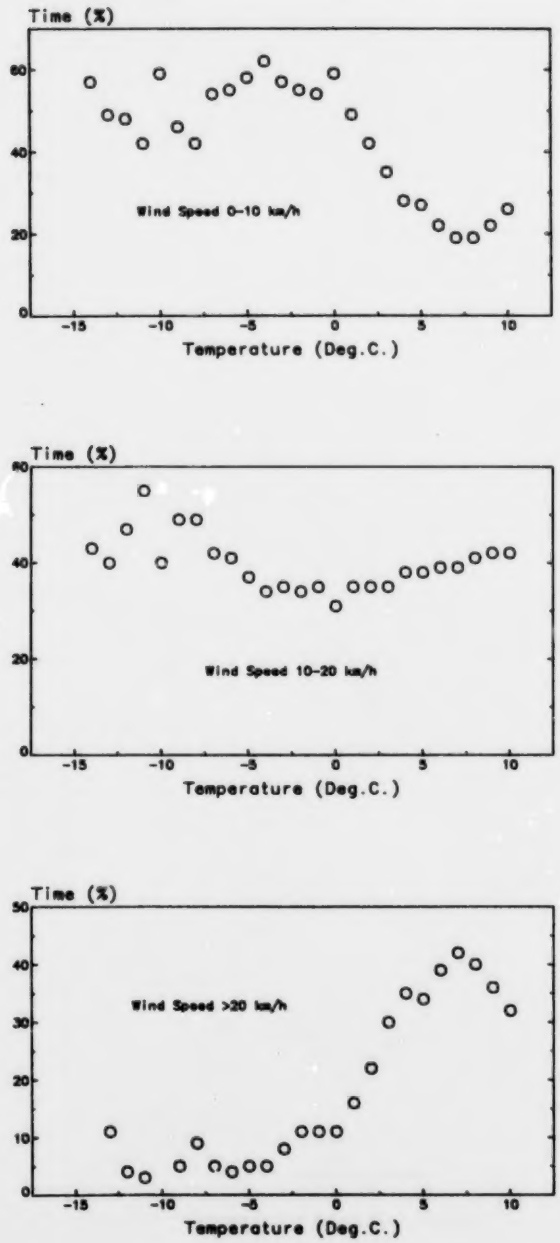
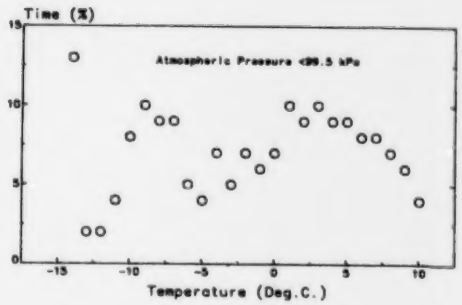
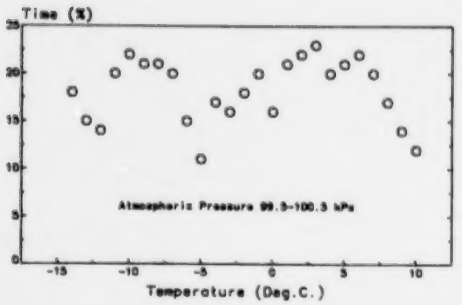
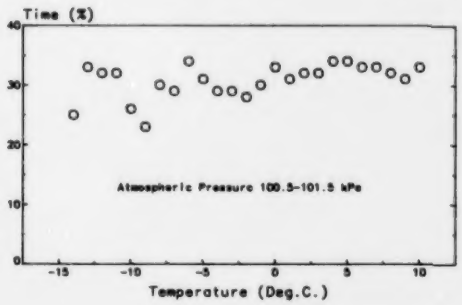
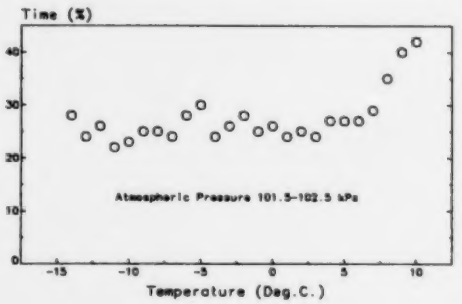



Figure A-2 (d) Wind Speed for Prince Rupert



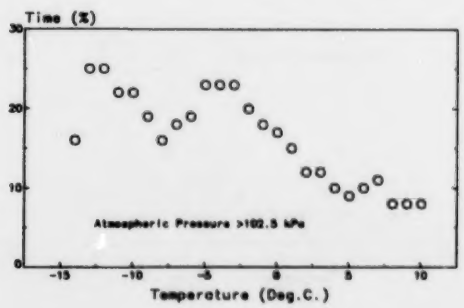




Figure A-2 (e) Atmospheric Pressure for Prince Rupert

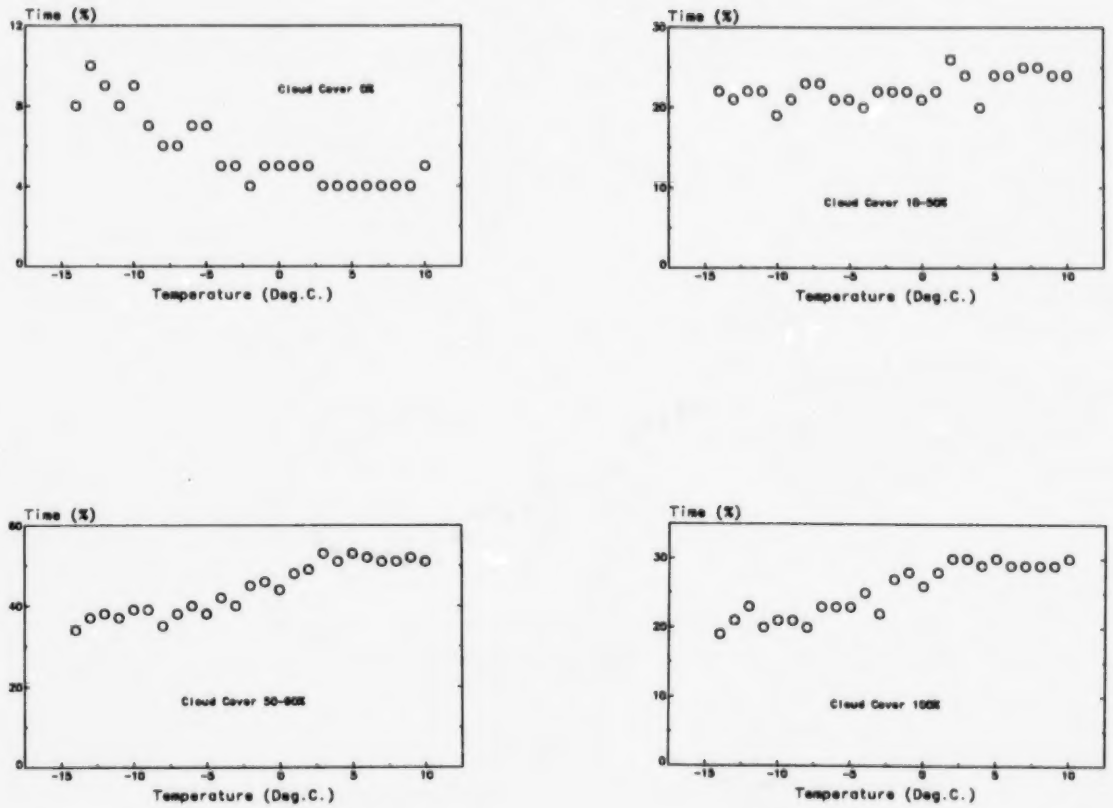



Figure A-3 (a) Cloud Cover for Calgary

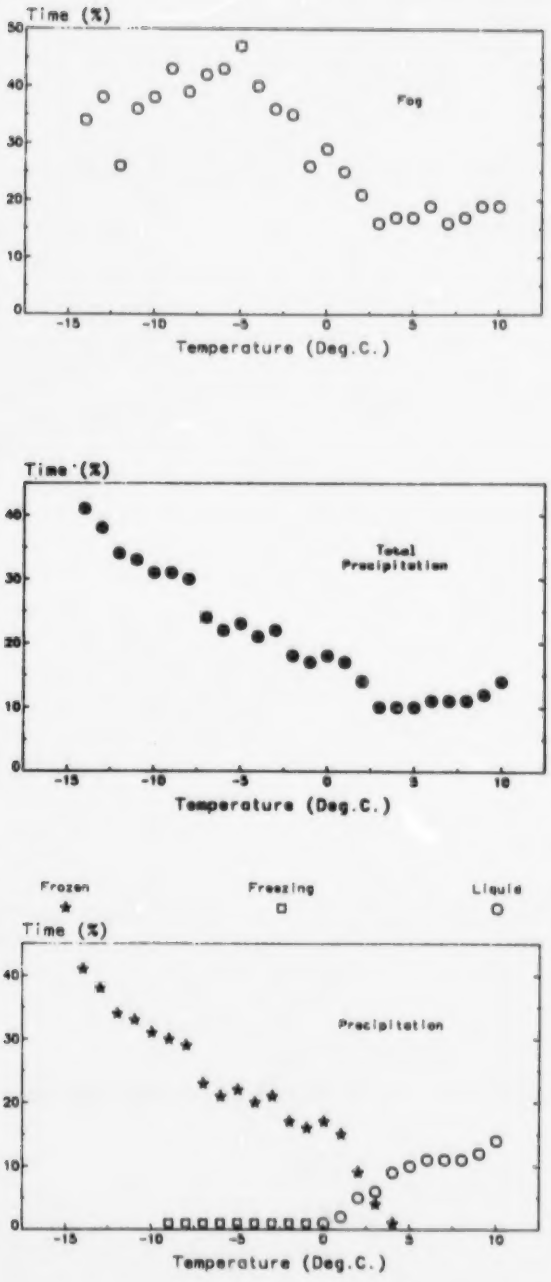



Figure A-3 (b) Fog and Precipitation for Calgary

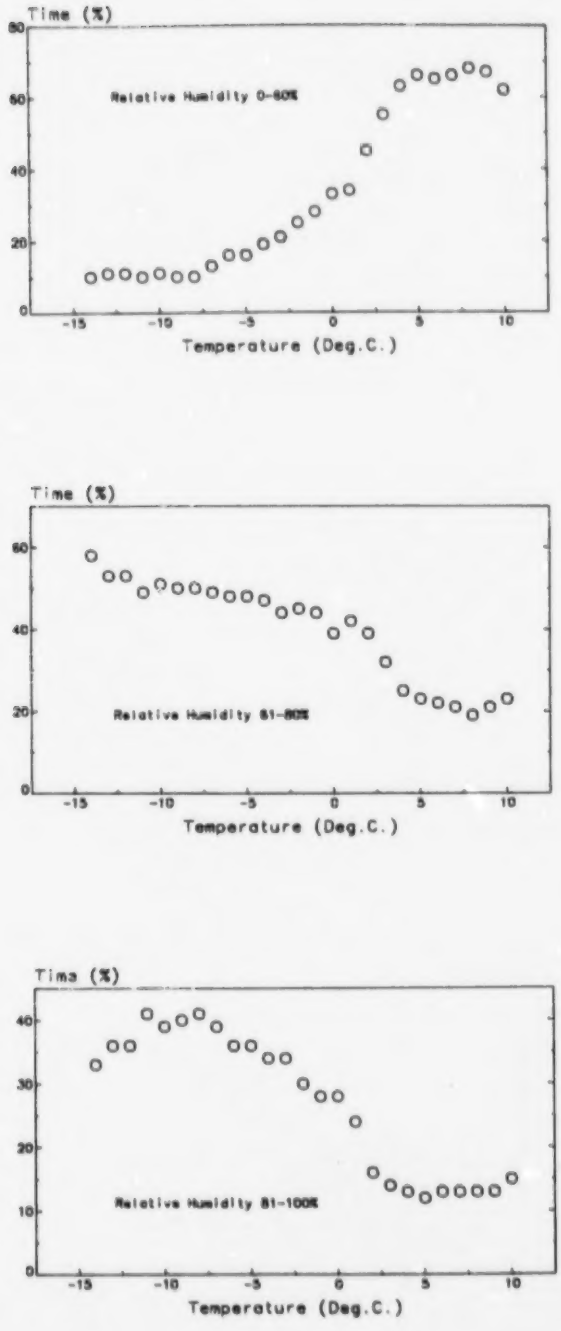
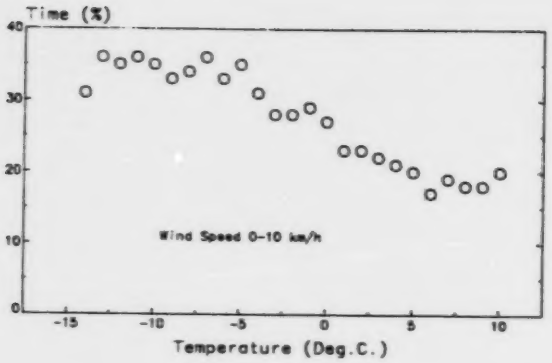
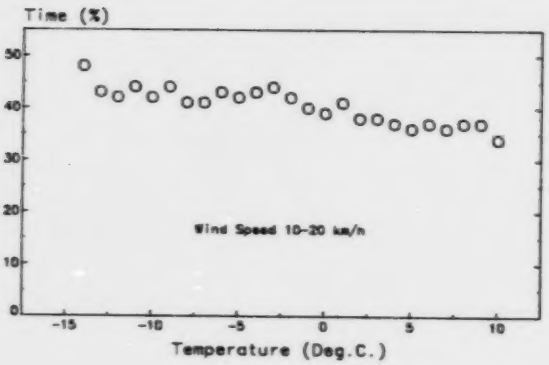



Figure A-3 (c) Relative Humidity for Calgary



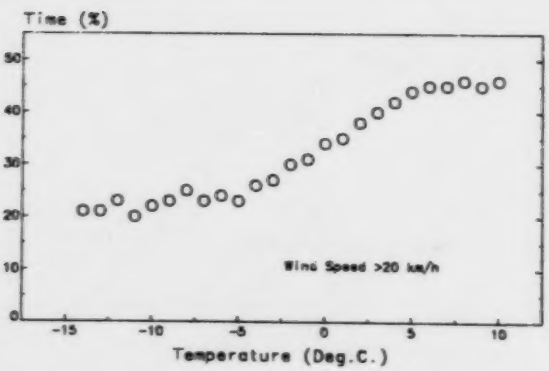
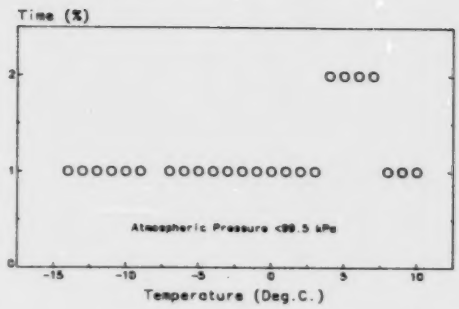
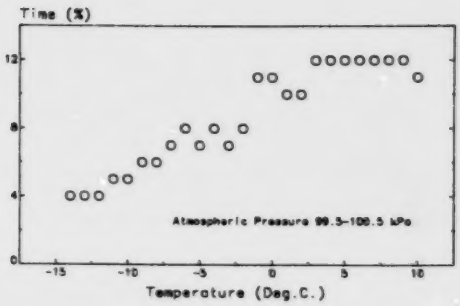
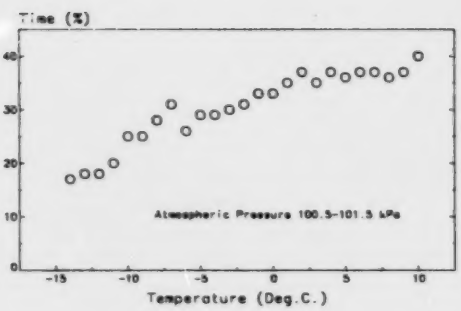
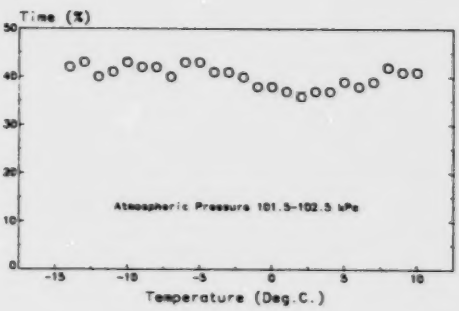




Figure A-3 (d) Wind Speed for Calgary



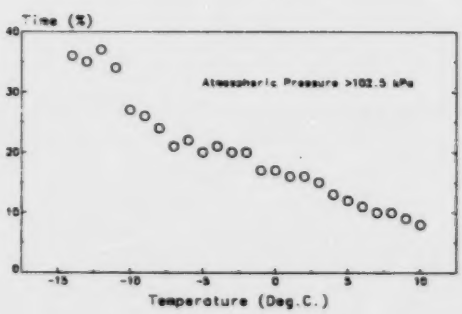




Figure A-3 (e) Atmospheric Pressure for Calgary

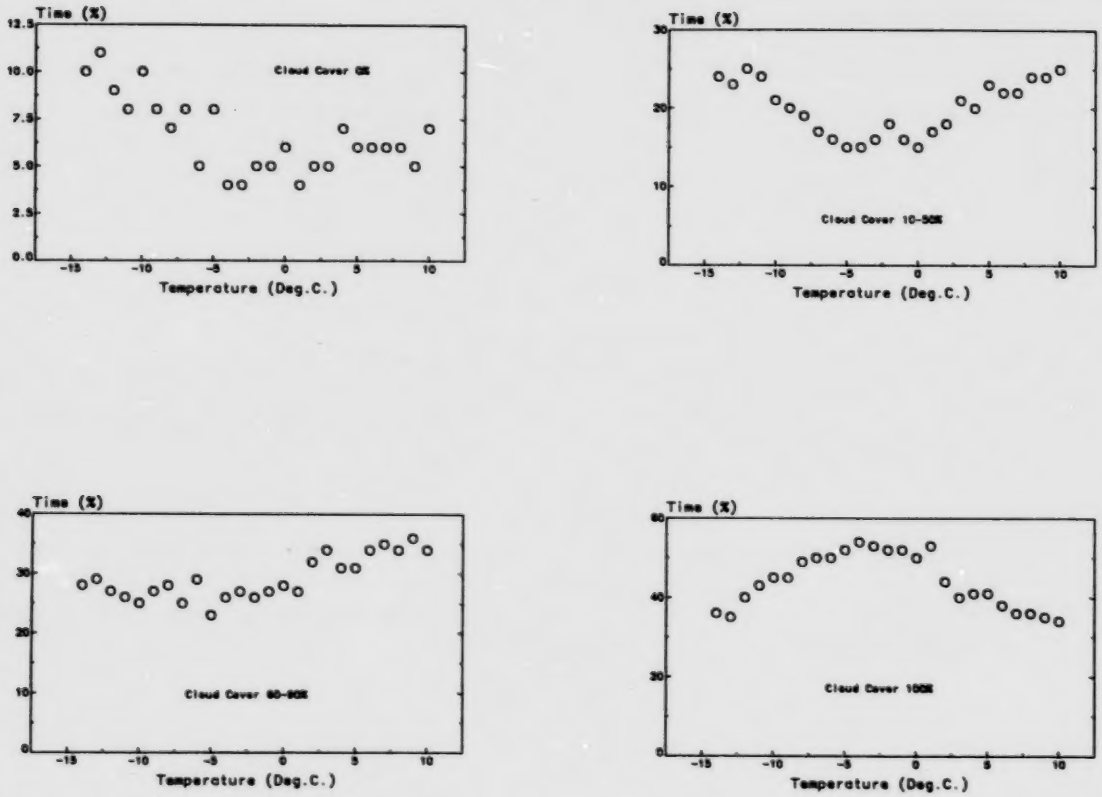



Figure A-4 (a) Cloud Cover for Winnipeg

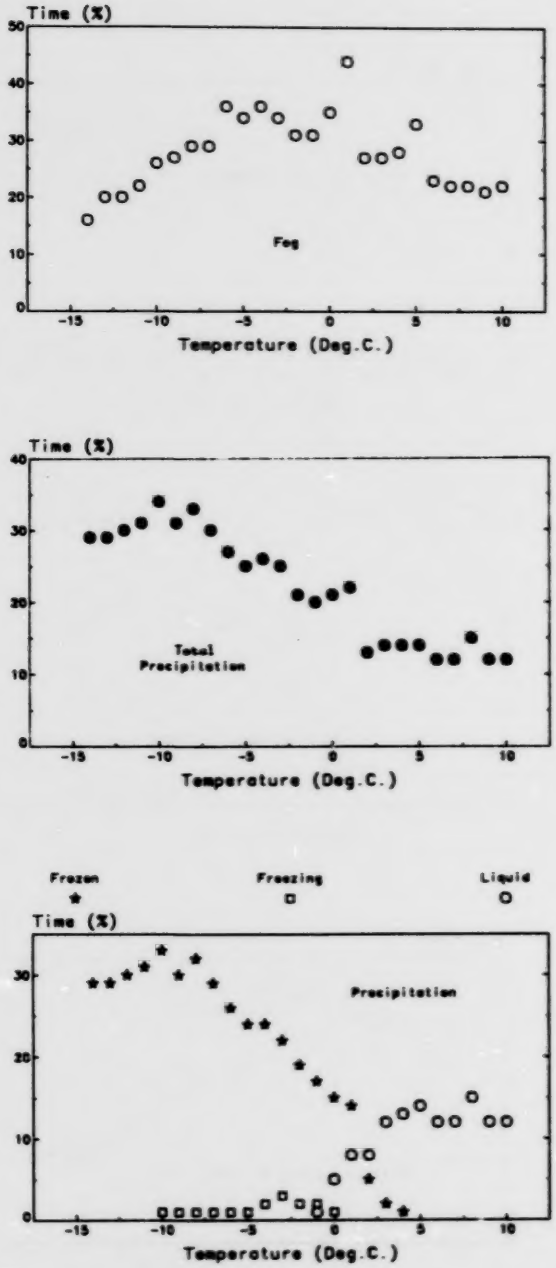



Figure A-4 (b) Fog and Precipitation for Winnipeg

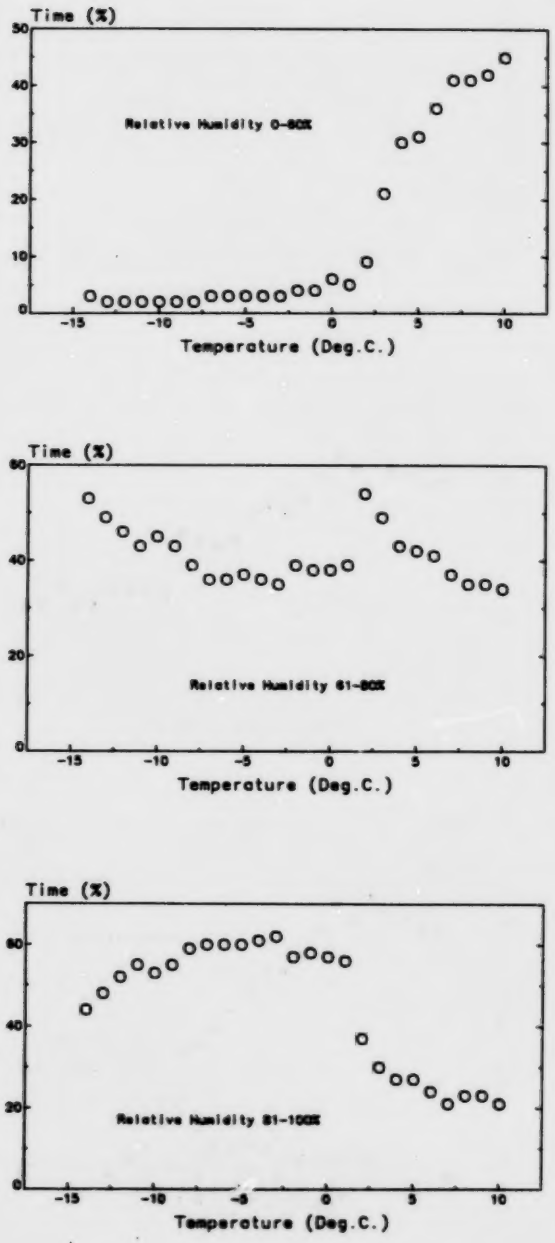



Figure A-4 (c) Relative Humidity for Winnipeg

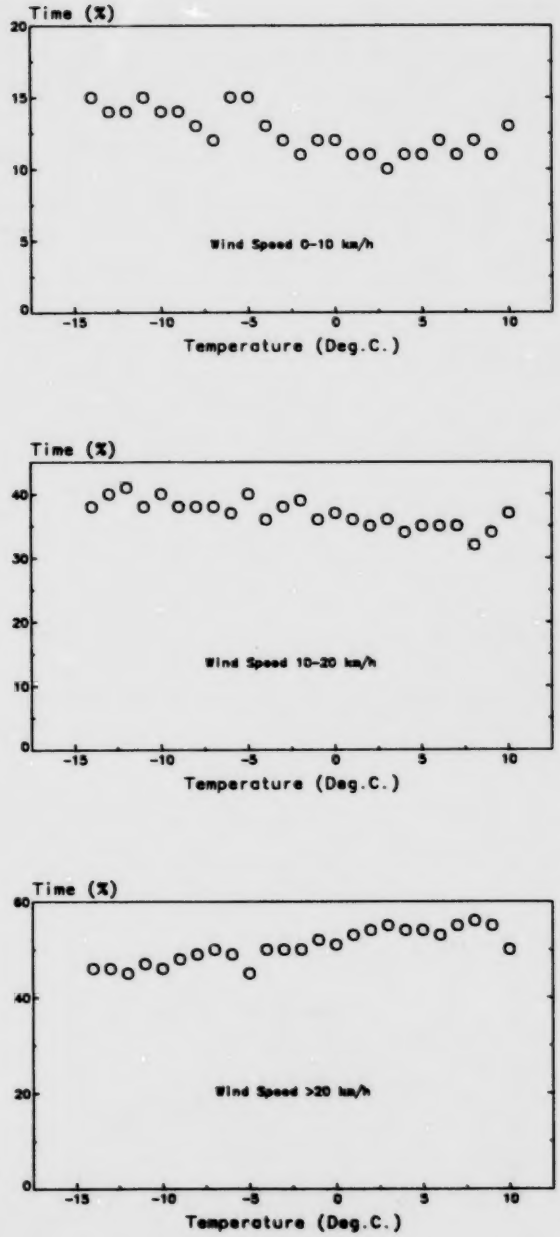



Figure A-4 (d) Wind Speed for Winnipeg

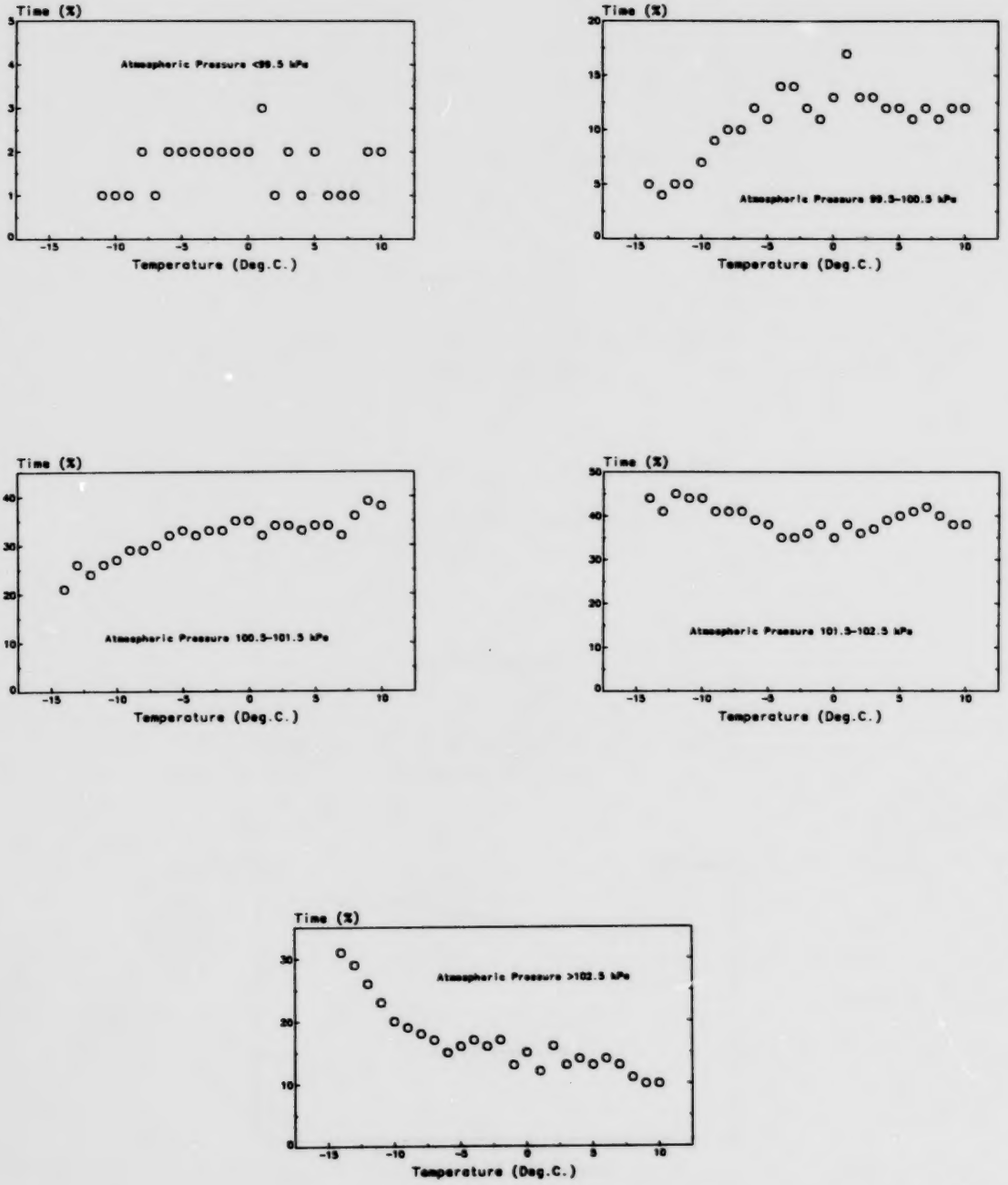



Figure A-4 (e) Atmospheric Pressure for Winnipeg

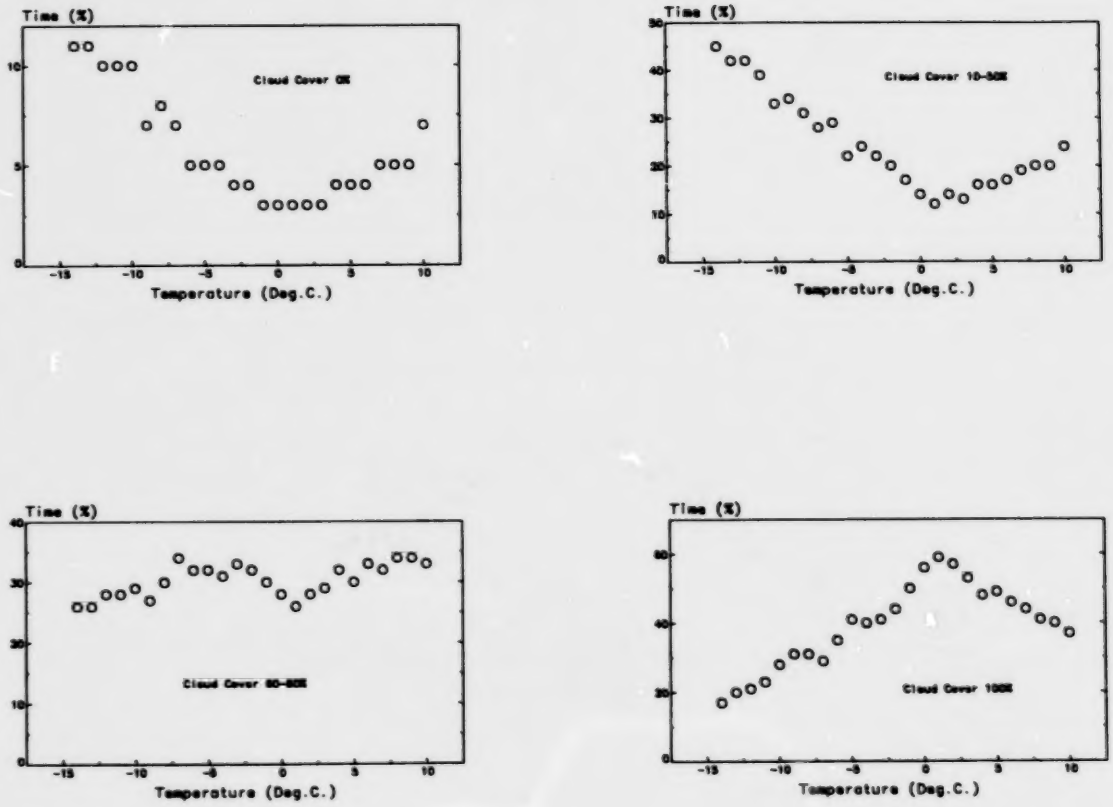
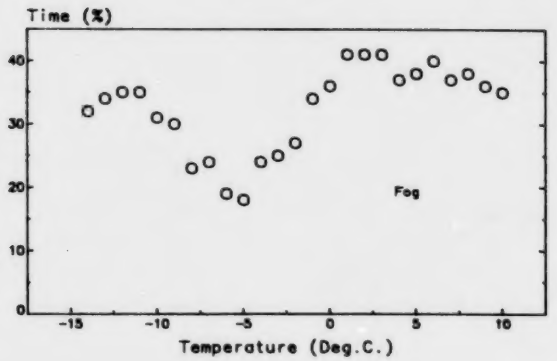
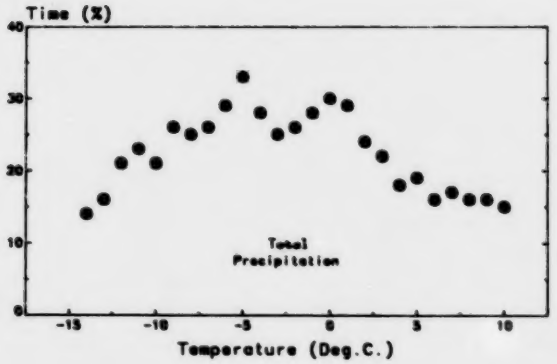



Figure A-5 (a) Cloud Cover for Toronto



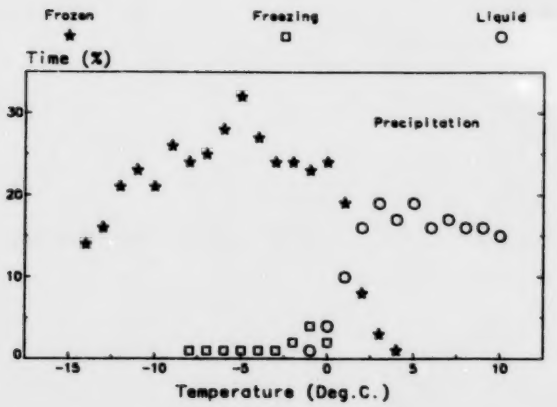




Figure A-5 (b) Fog and Precipitation for Toronto

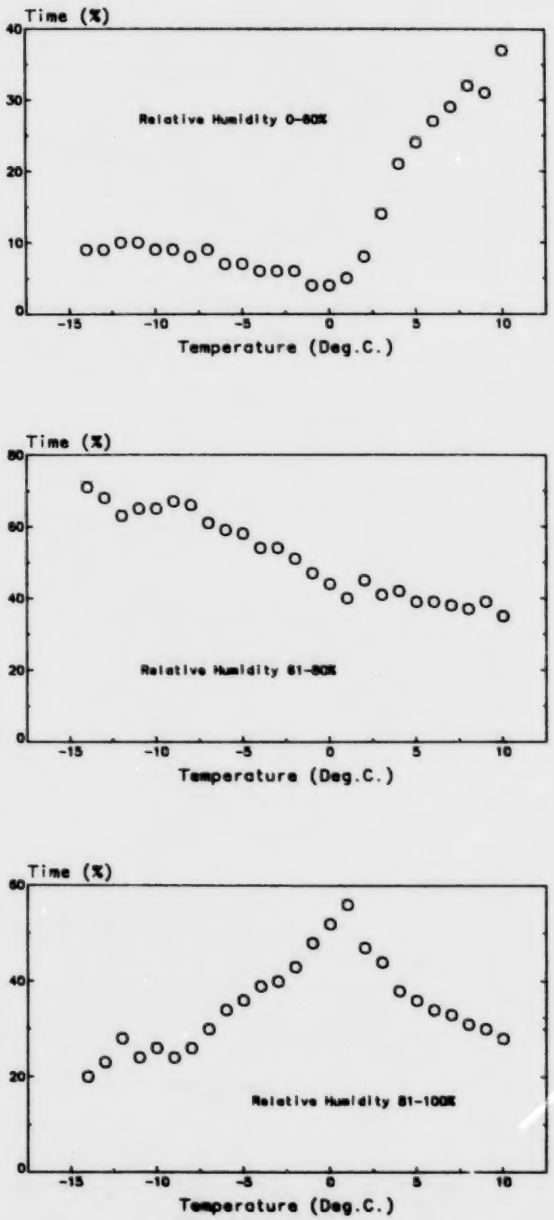



Figure A-5 (c) Relative Humidity for Toronto

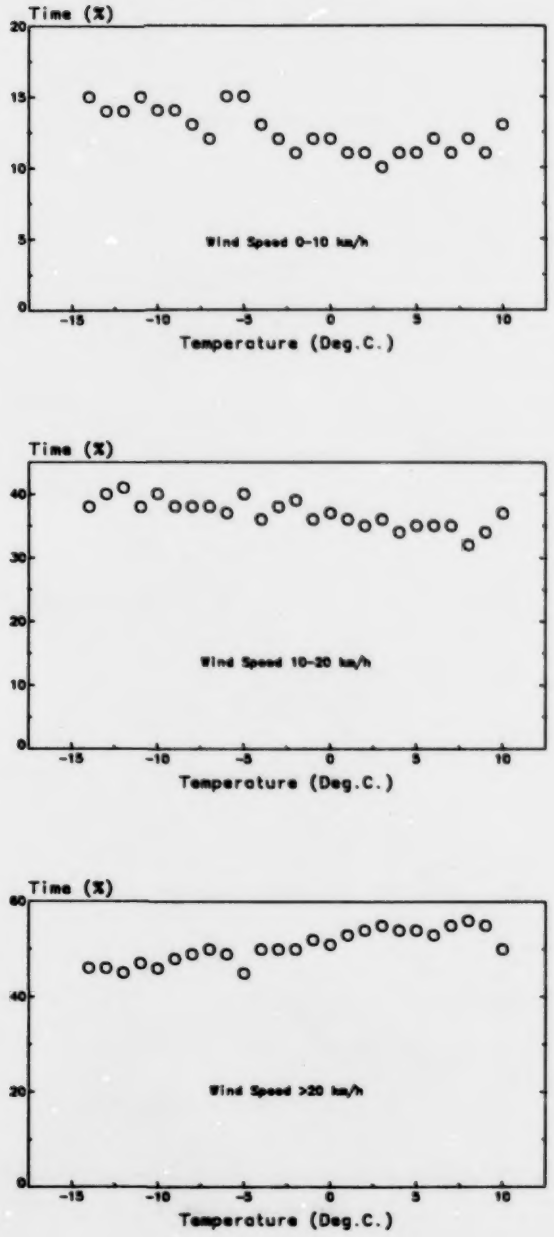



Figure A-5 (d) Wind Speed for Toronto

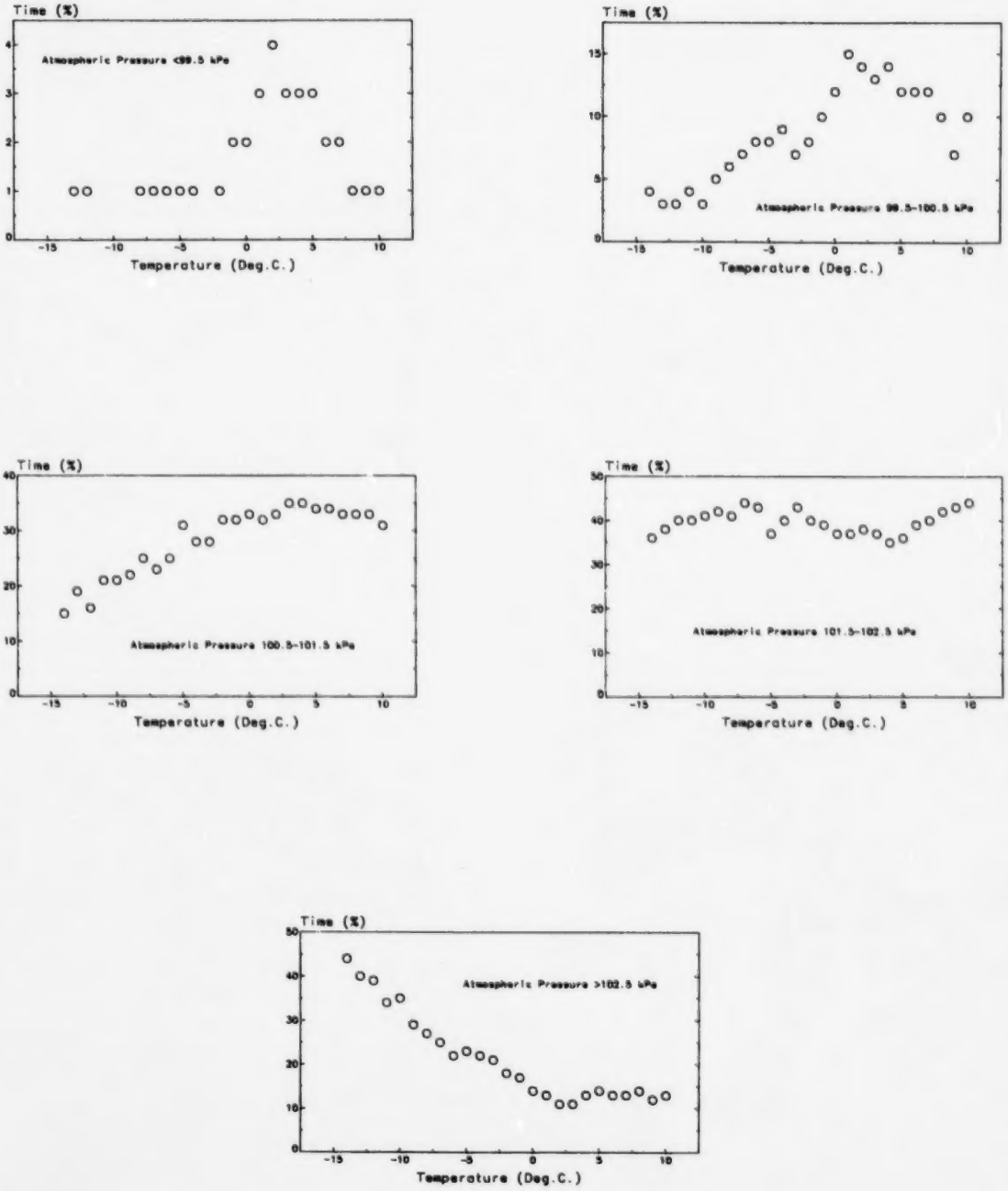



Figure A-5 (e) Atmospheric Pressure for Toronto

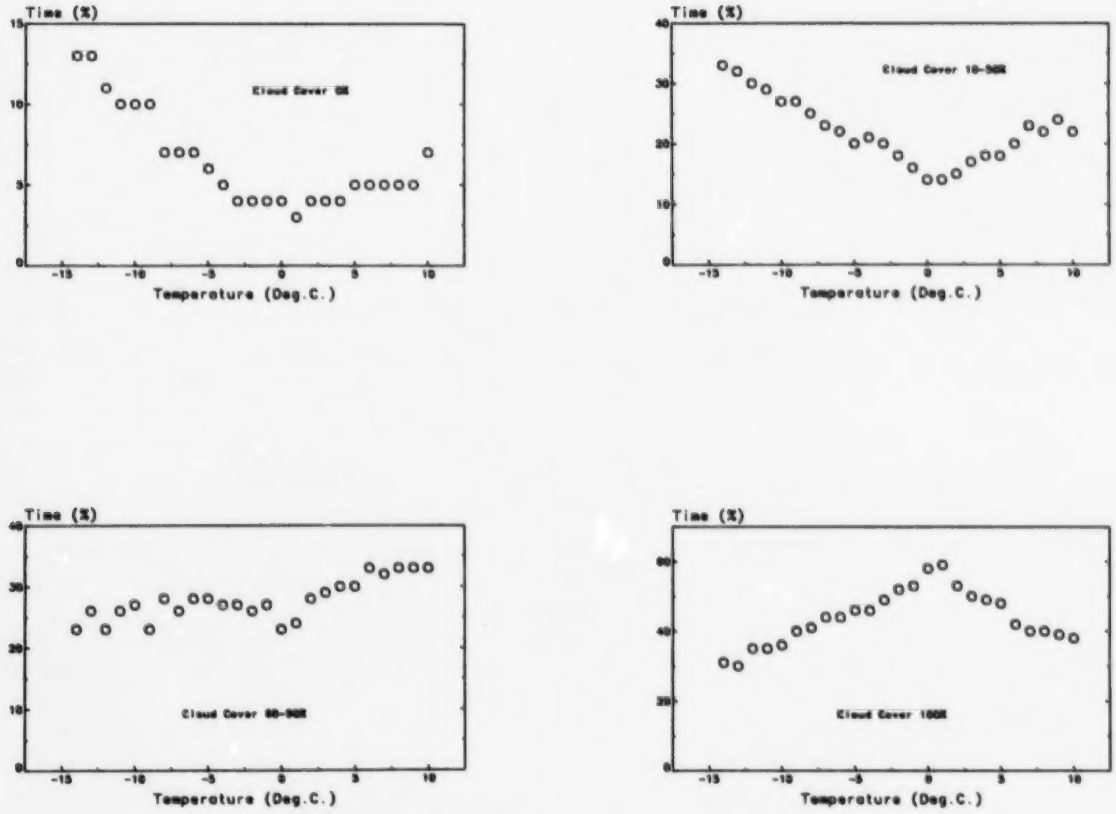



Figure A-6 (a) Cloud Cover for Ottawa

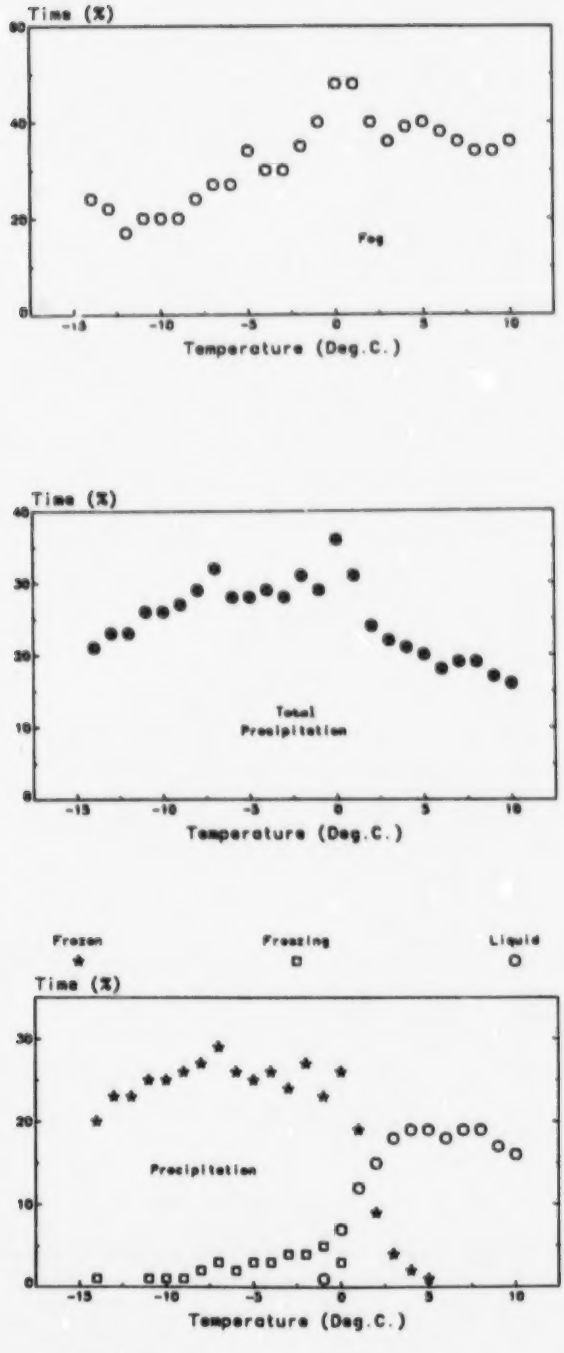



Figure A-6 (b) Fog and Precipitation for Ottawa

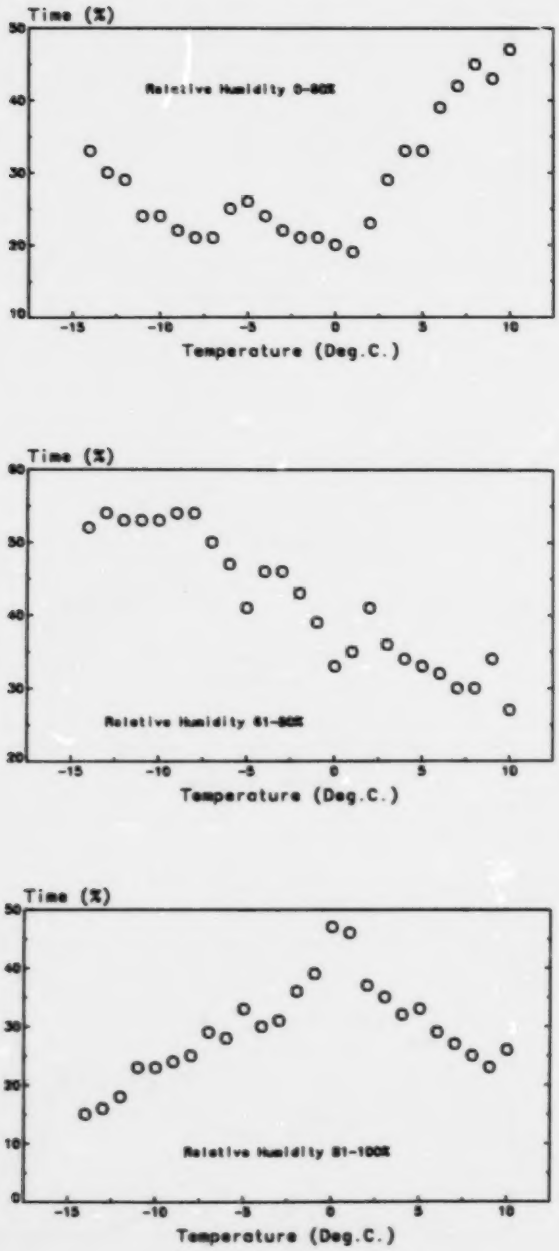



Figure A-6 (c) Relative Humidity for Ottawa

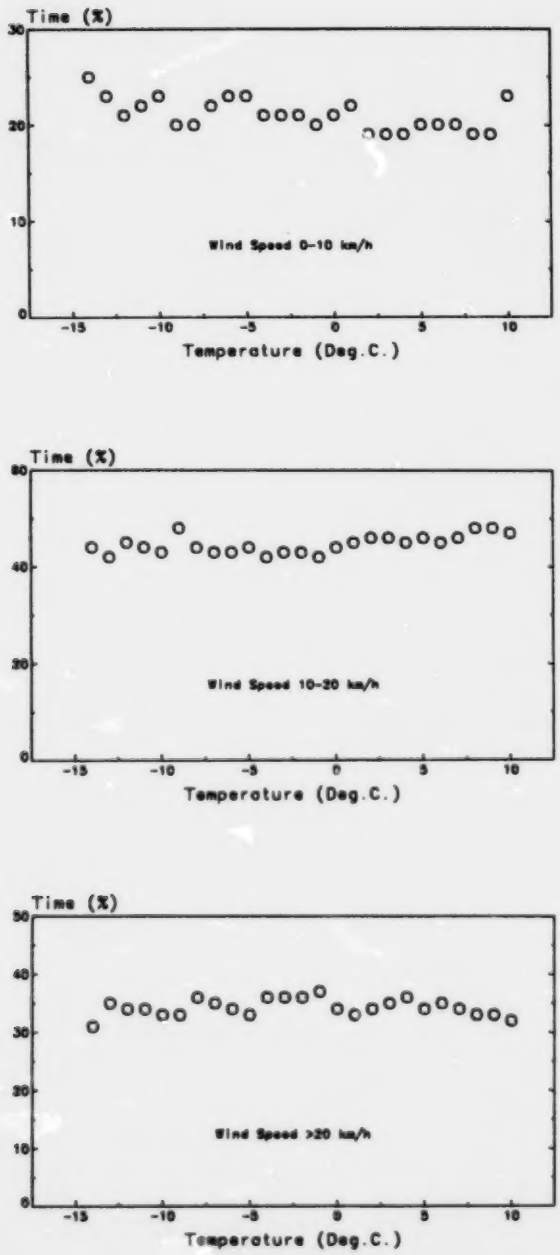
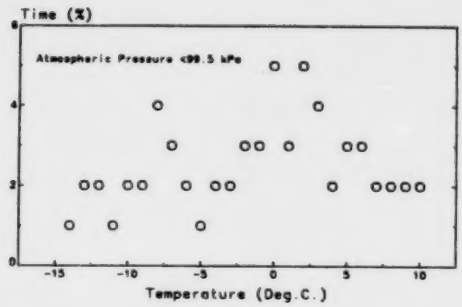
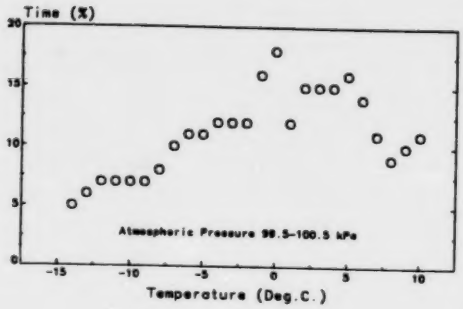
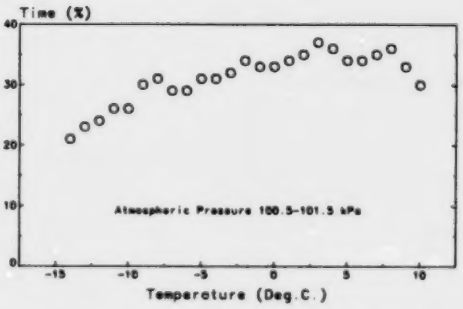
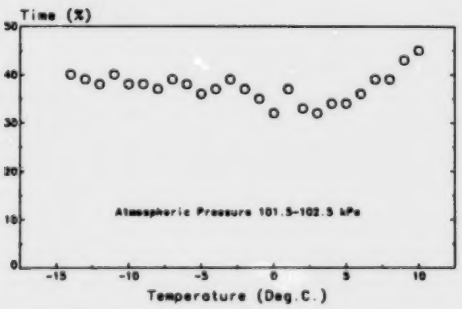



Figure A-6 (d) Wind Speed for Ottawa



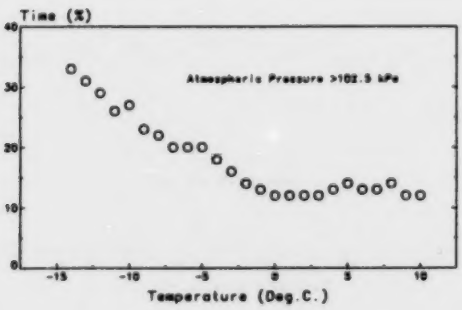




Figure A-6 (e) Atmospheric Pressure for Ottawa

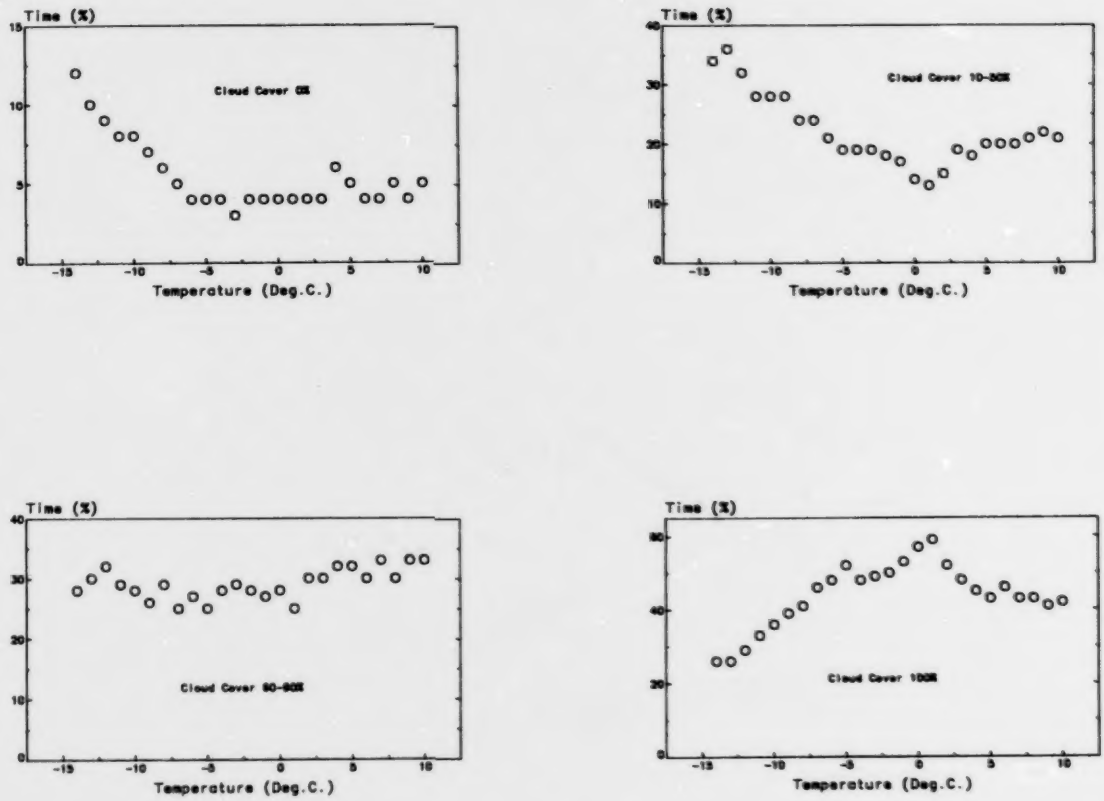



Figure A-7 (a) Cloud Cover for Québec

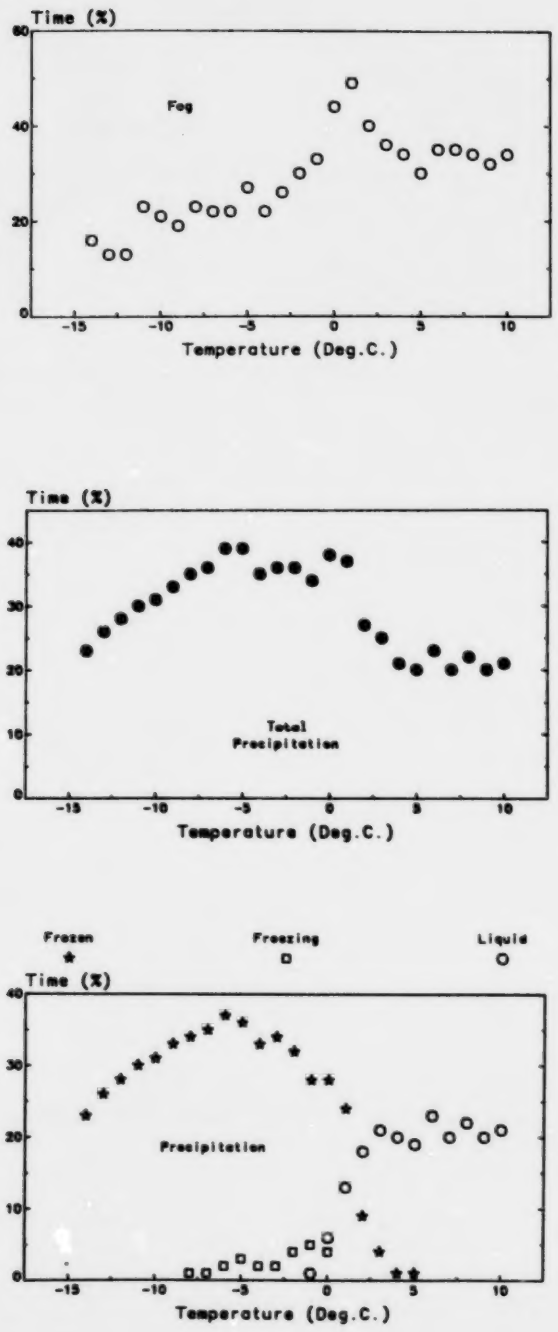



Figure A-7 (b) Fog and Precipitation for Québec

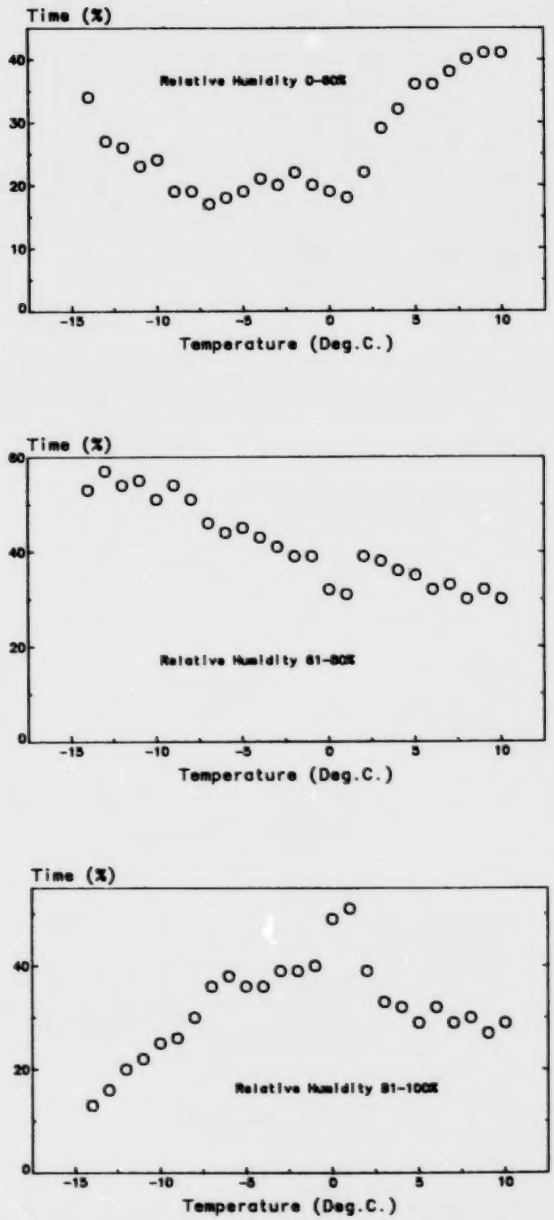
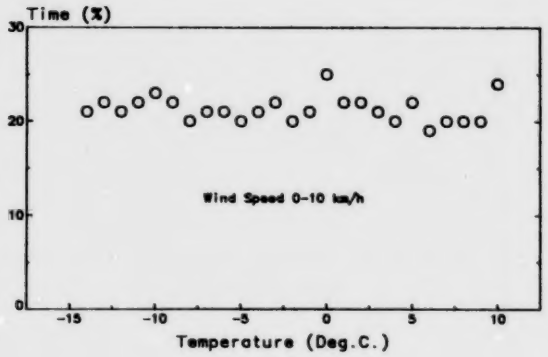
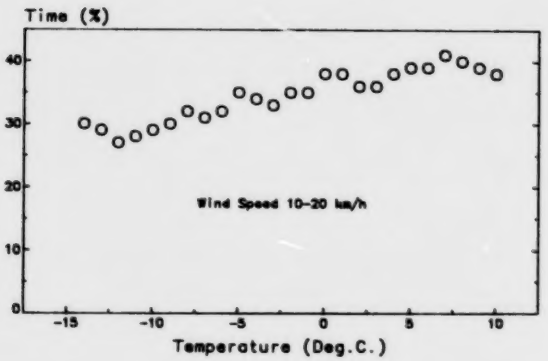



Figure A-7 (c) Relative Humidity for Québec



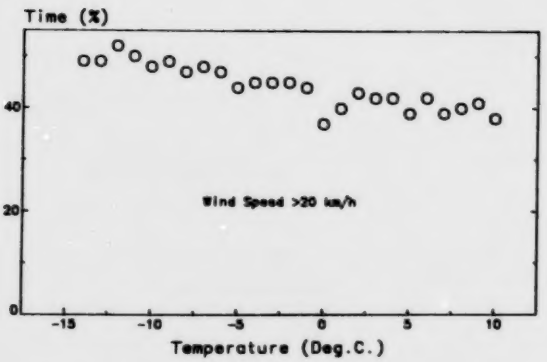
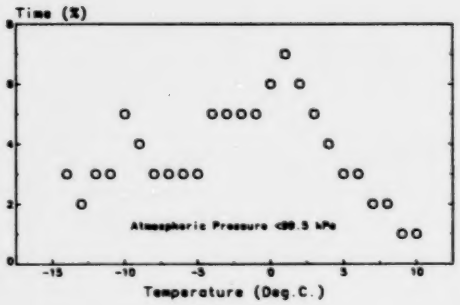
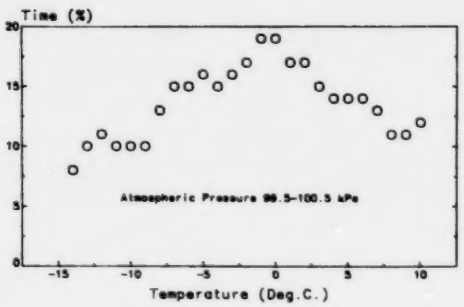
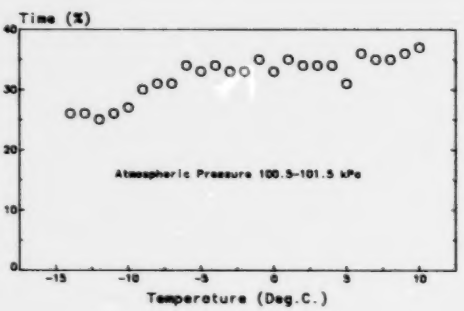
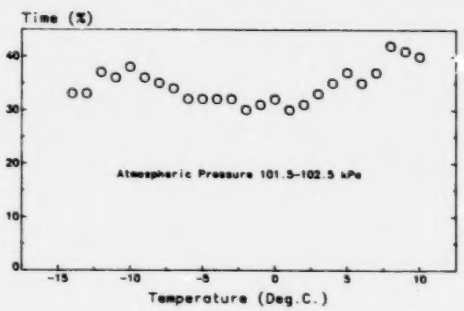




Figure A-7 (d) Wind Speed for Québec



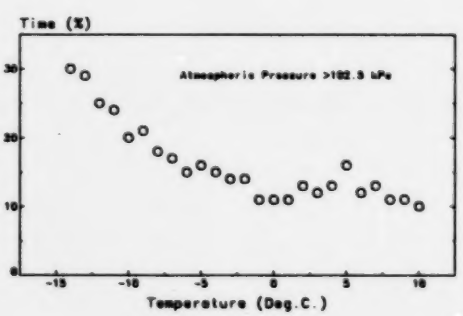




Figure A-7 (e) Atmospheric Pressure for Québec

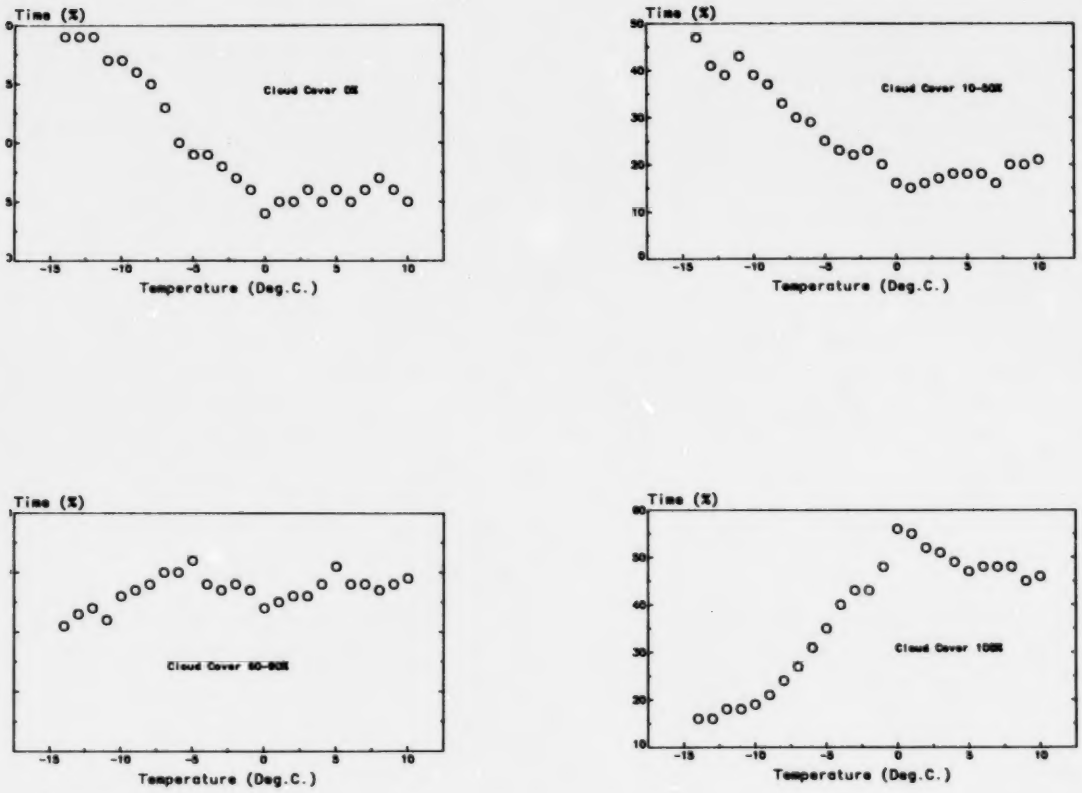



Figure A-8 (a) Cloud Cover for Saint John

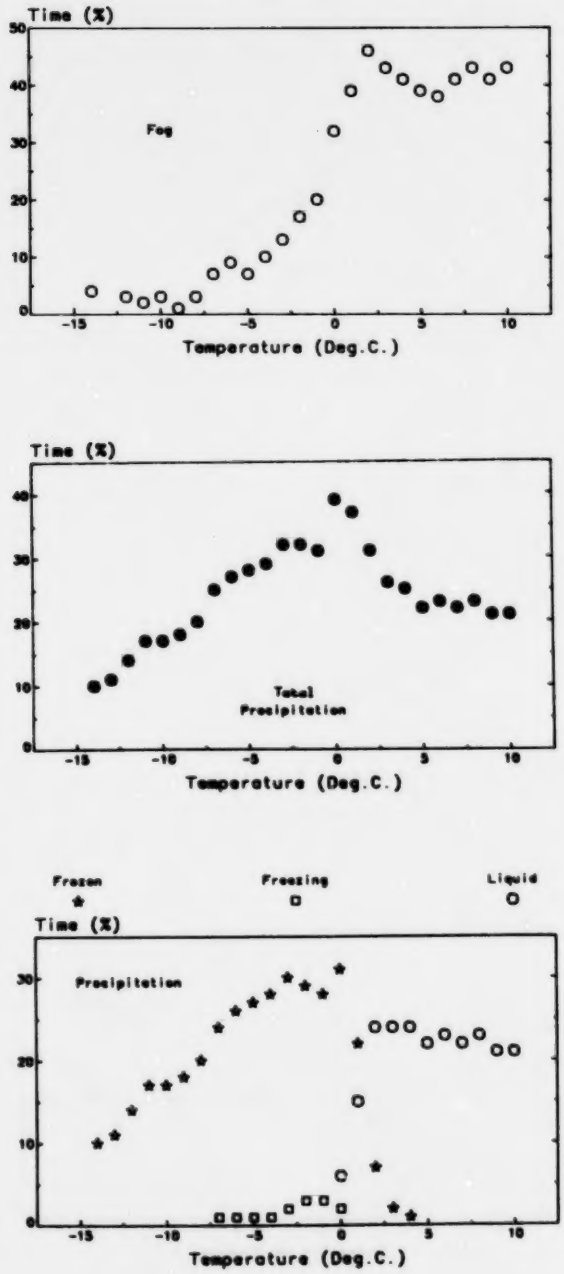
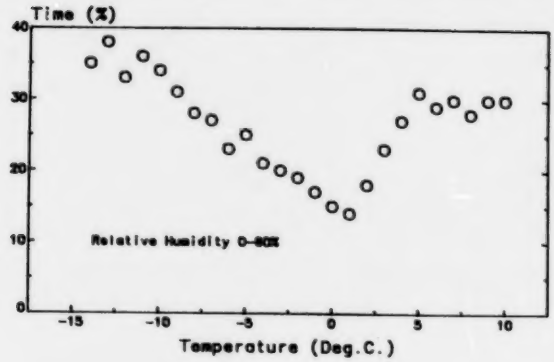
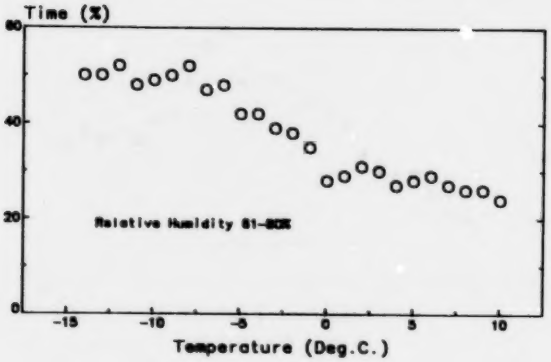



Figure A-8 (b) Fog and Precipitation for Saint John



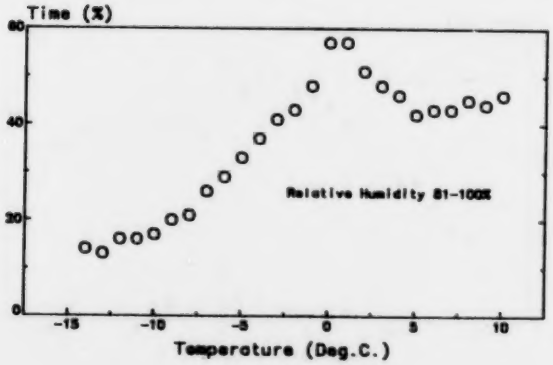




Figure A-8 (c) Relative Humidity for Saint John

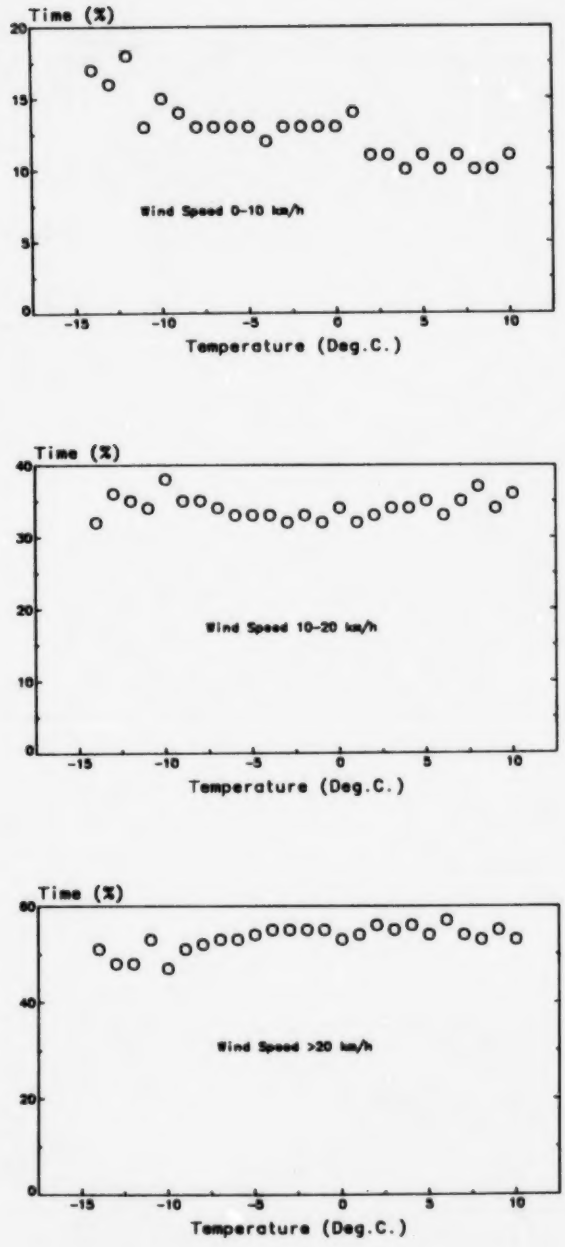
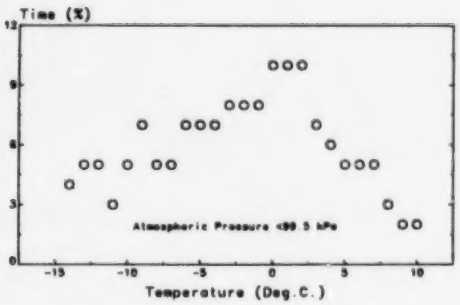
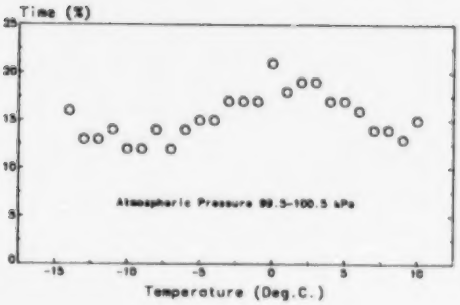
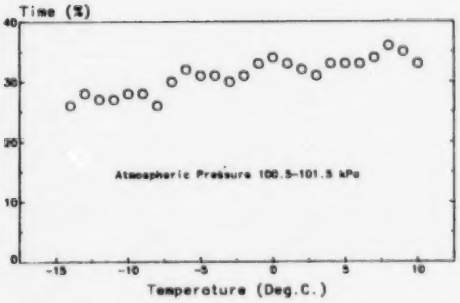
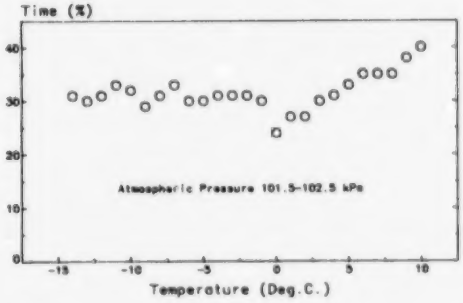



Figure A-8 (d) Wind Speed for Saint John



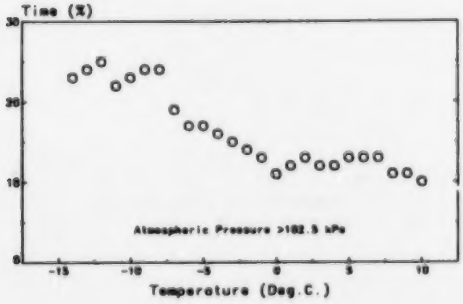




Figure A-8 (e) Atmospheric Pressure for Saint John

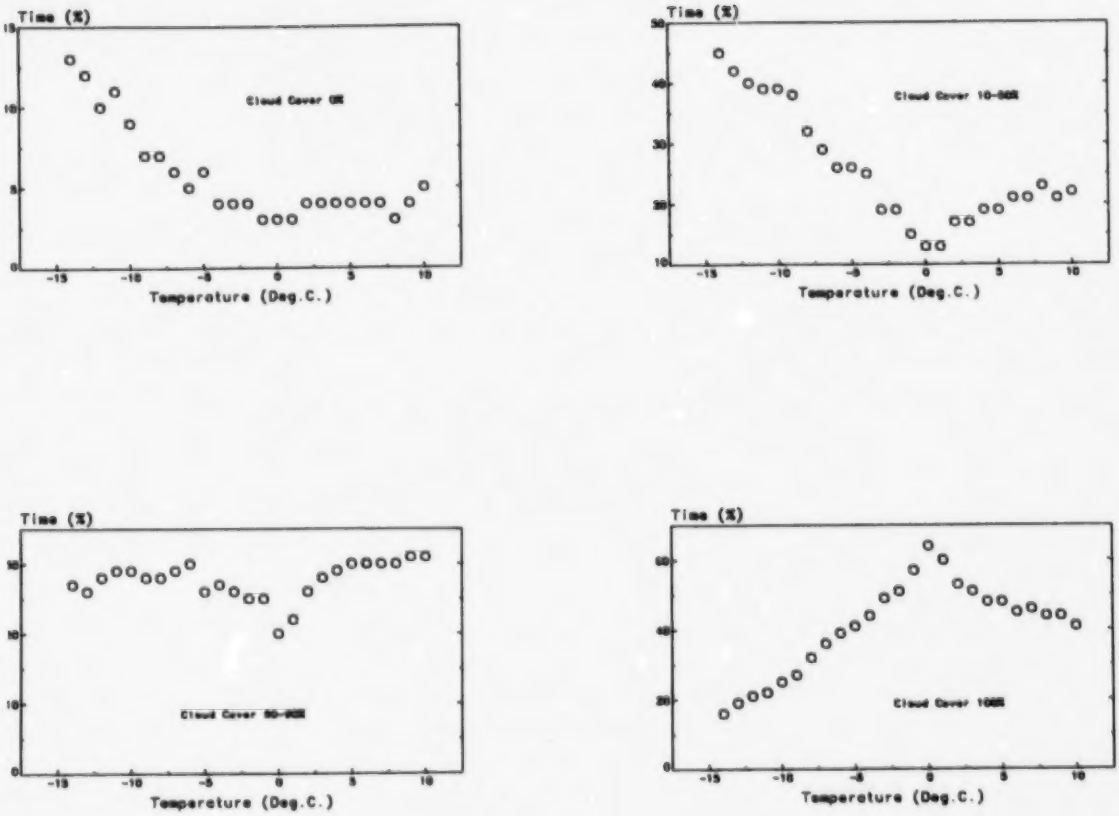
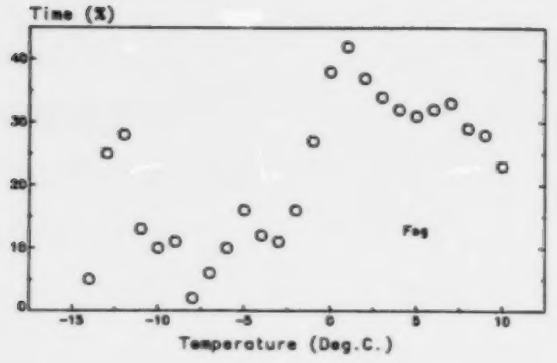
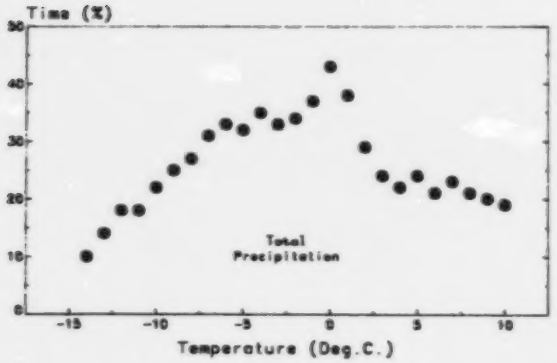



Figure A-9 (a) Cloud Cover for Summerside



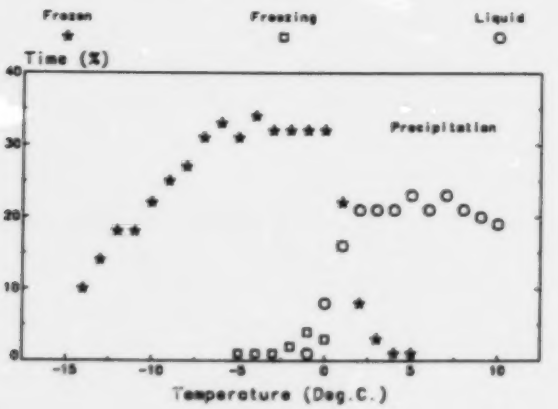




Figure A-9 (b) Fog and Precipitation for Summerside

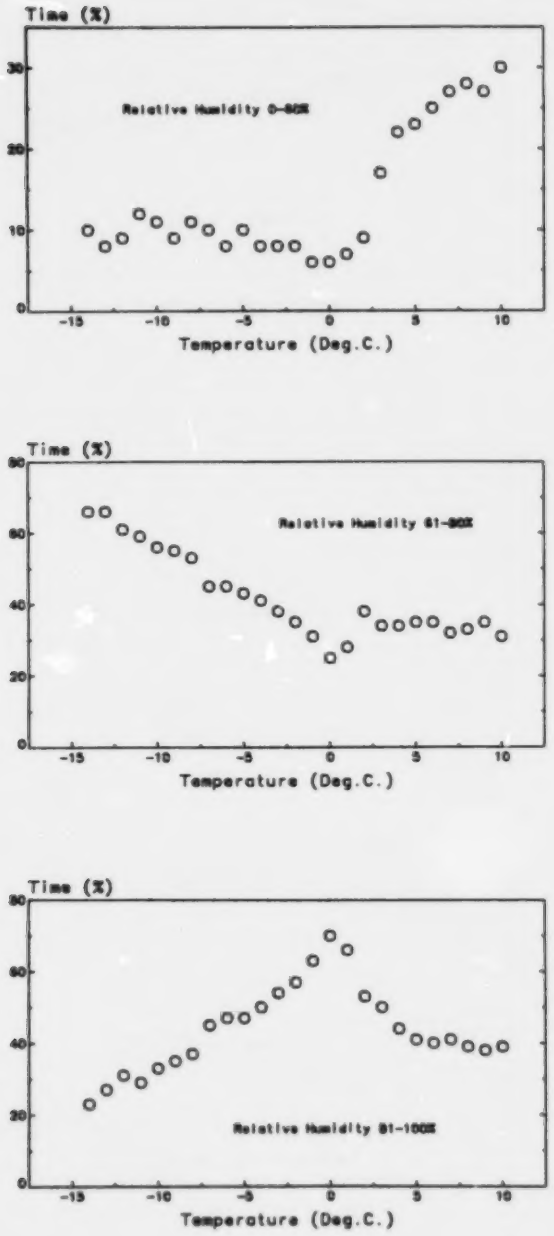



Figure A-9 (c) Relative Humidity for Summerside

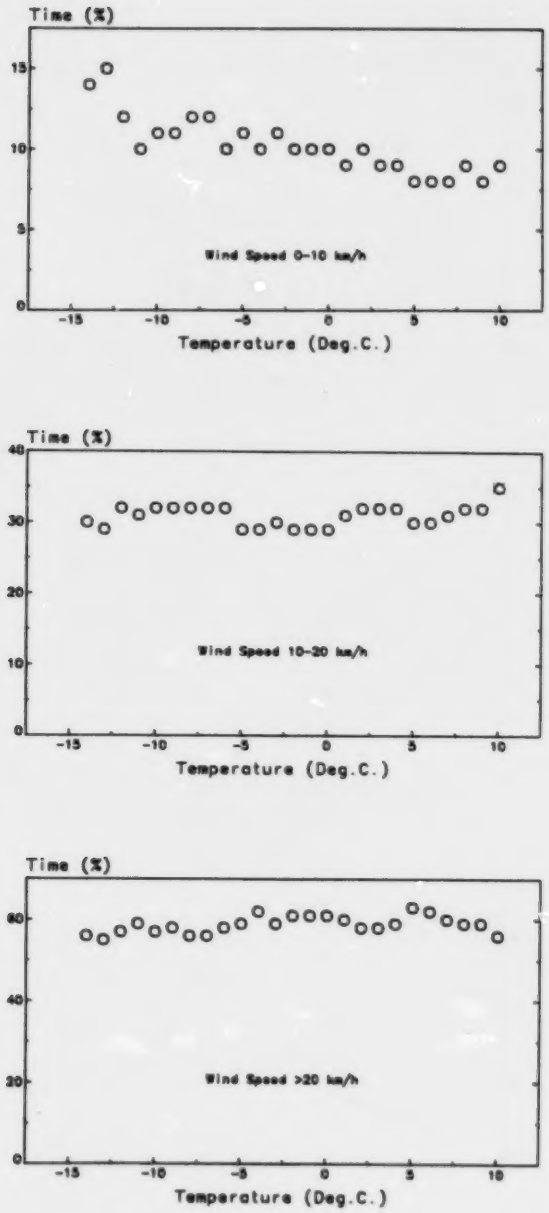



Figure A-9 (d) Wind Speed for Summerside

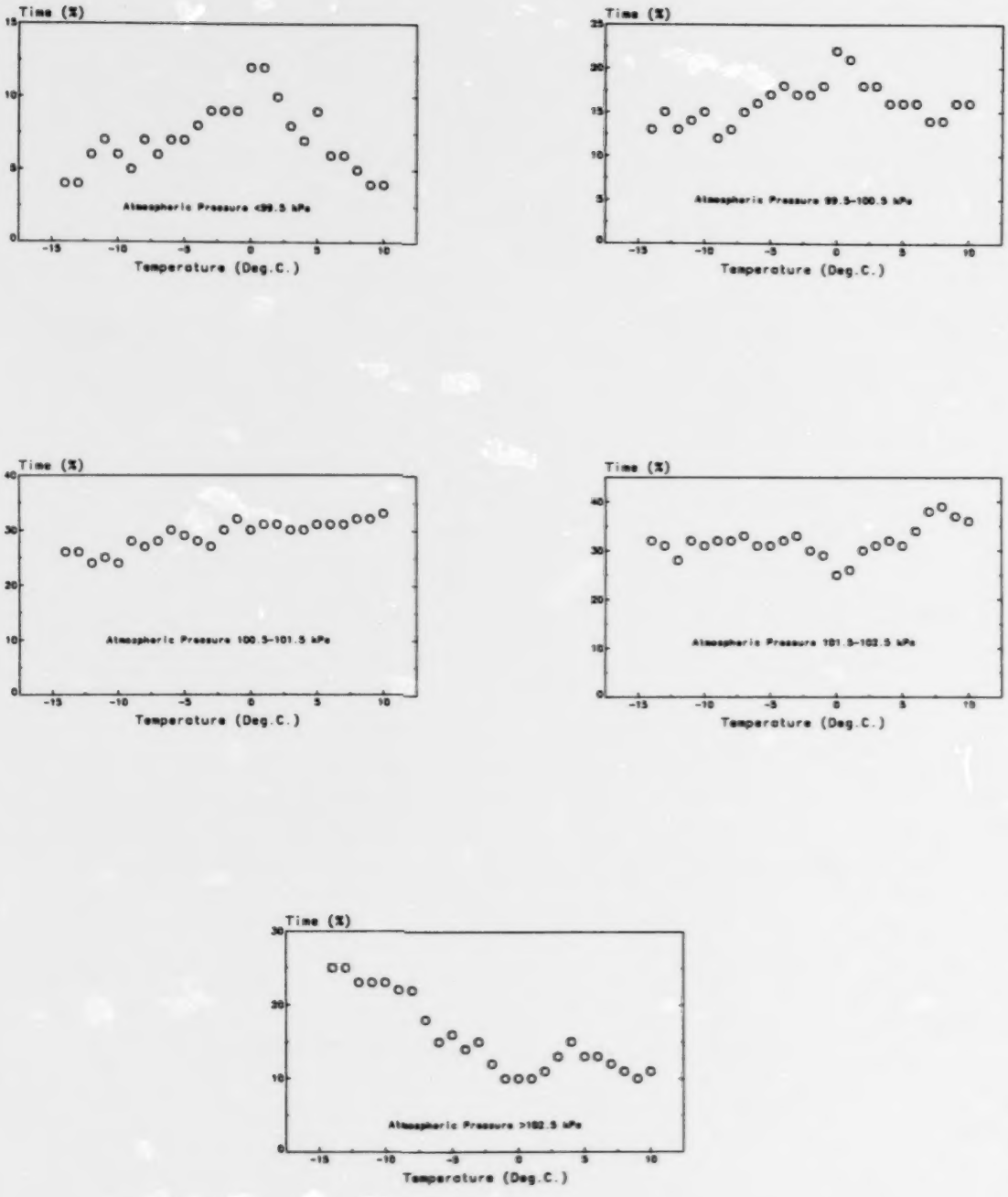



Figure A-9 (e) Atmospheric Pressure for Summerside

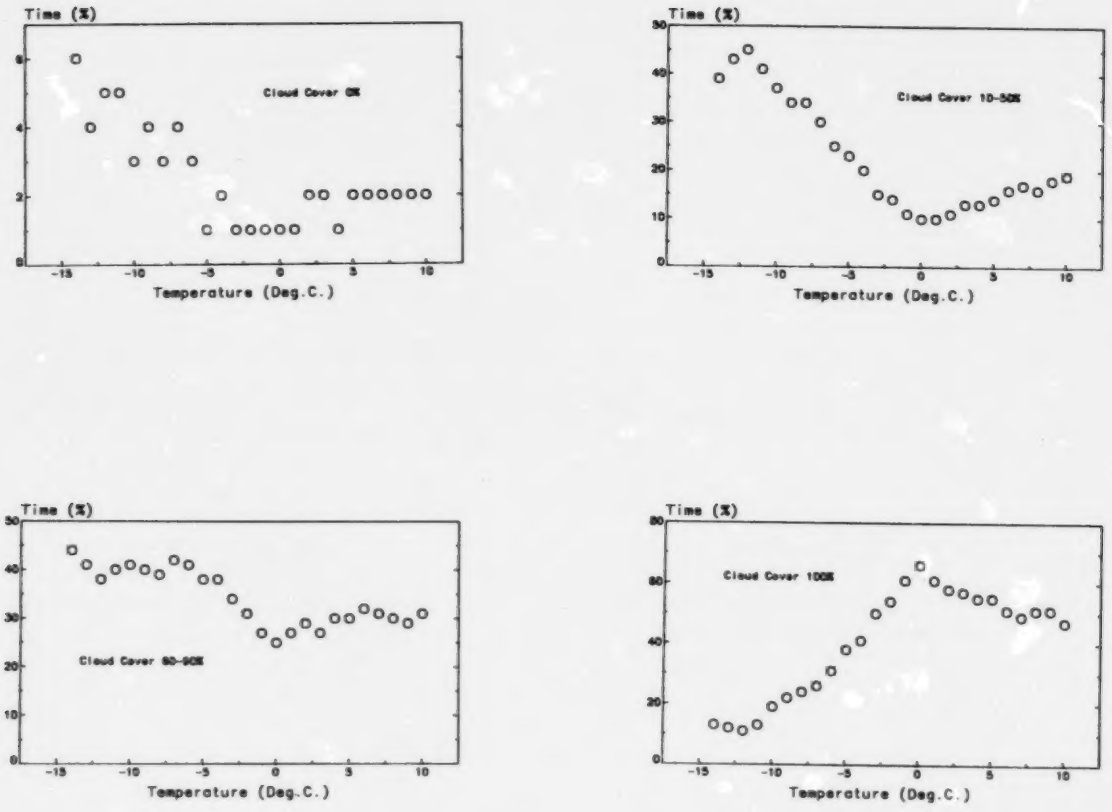



Figure A-10 (a) Cloud Cover for St. John's

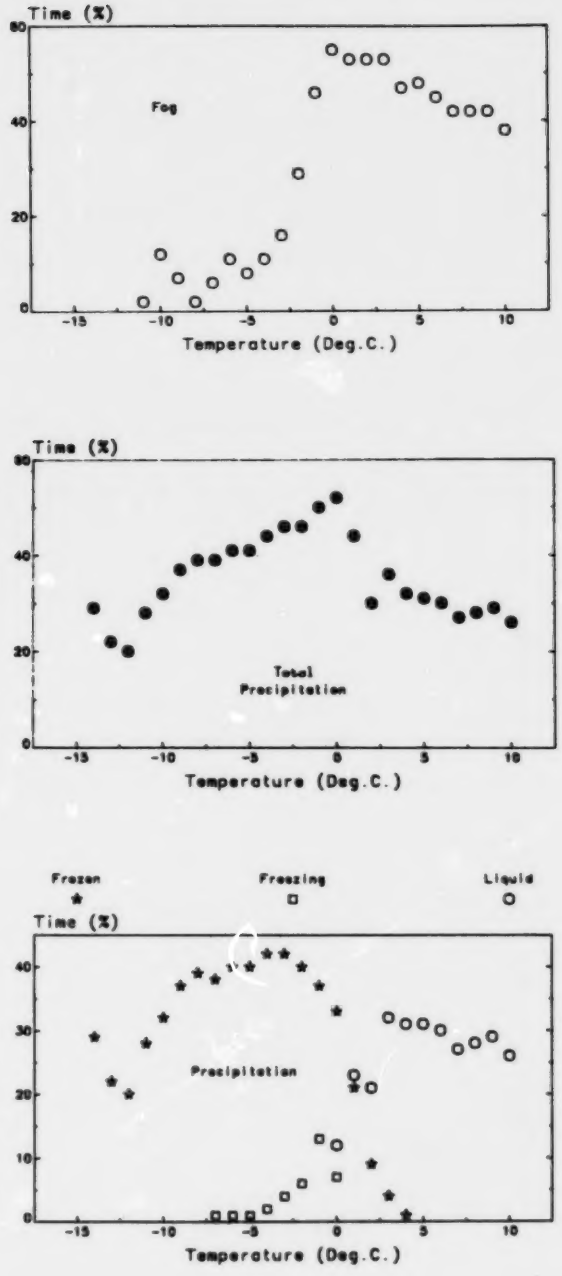
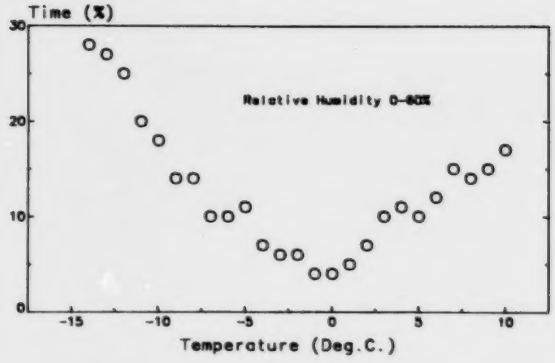
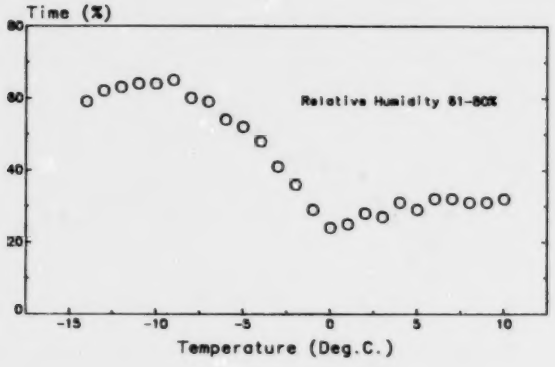



Figure A-10 (b) Fog and Precipitation St. John's



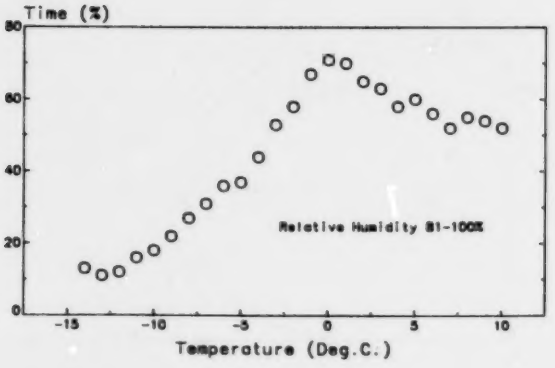




Figure A-10 (c) Relative Humidity for St. John's

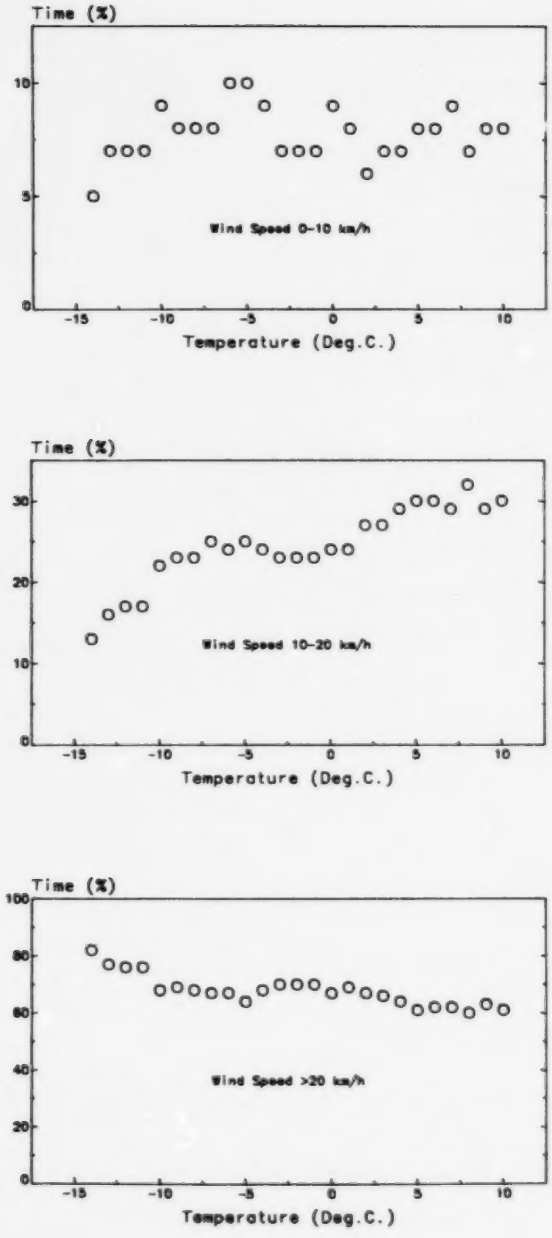
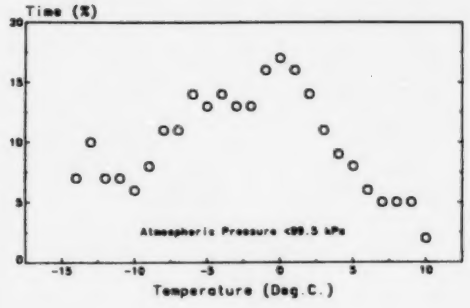
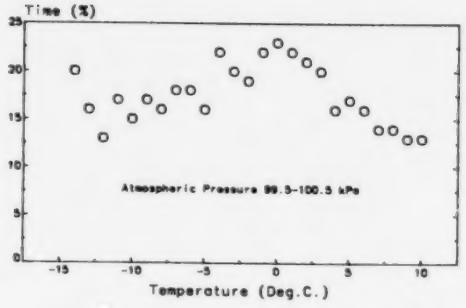
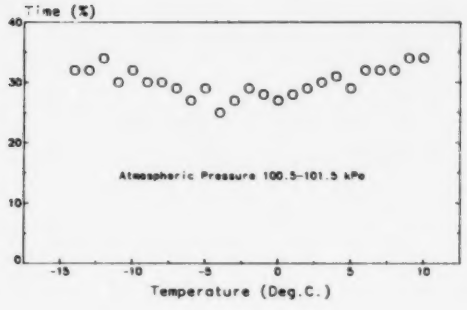
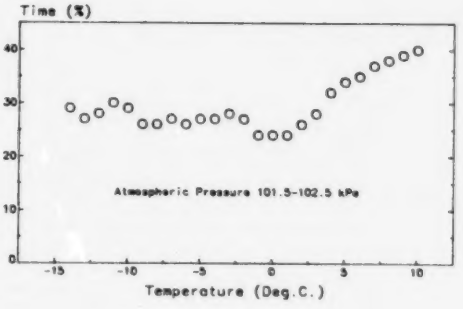



Figure A-10 (d) Wind Speed for St. John's



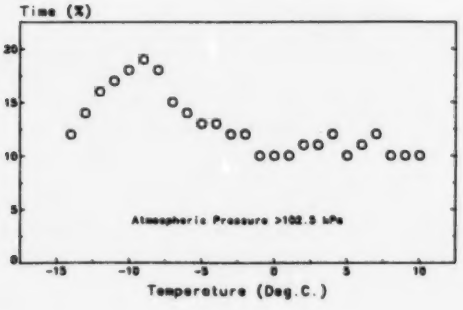




Figure A-10 (e) Atmospheric Pressure for St. John's

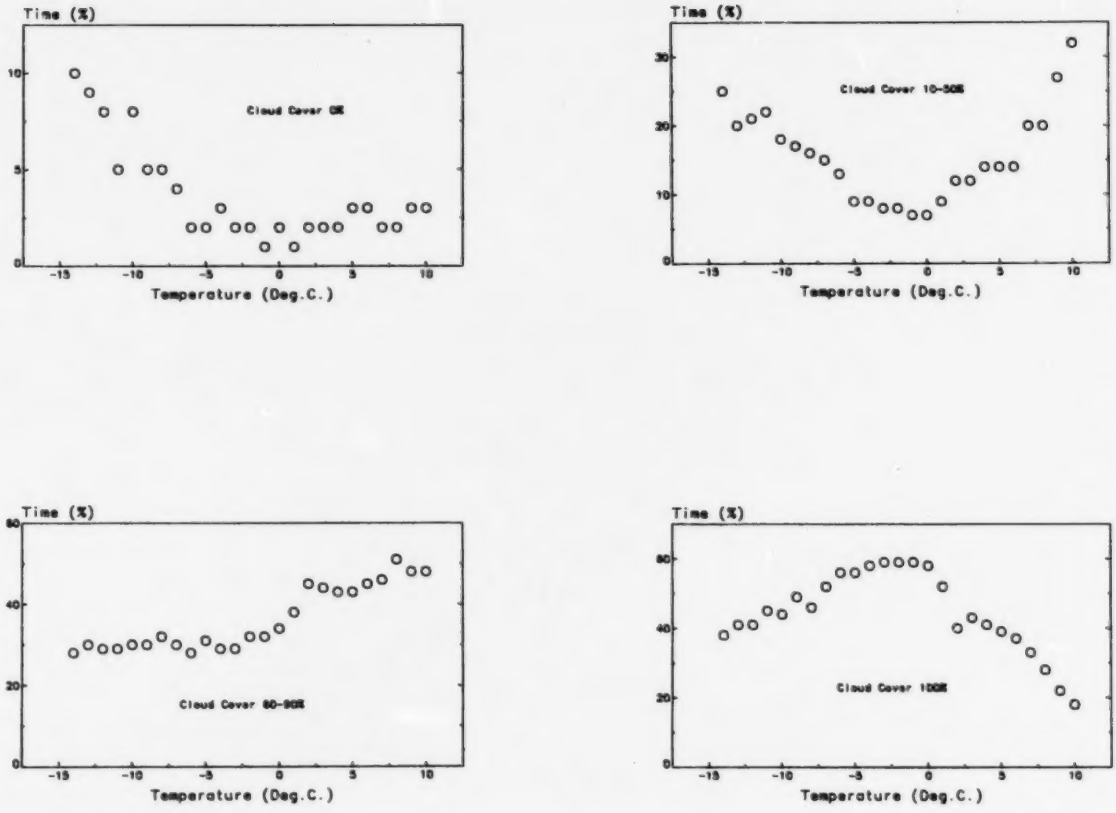



Figure A-11 (a) Cloud Cover for Cambridge Bay

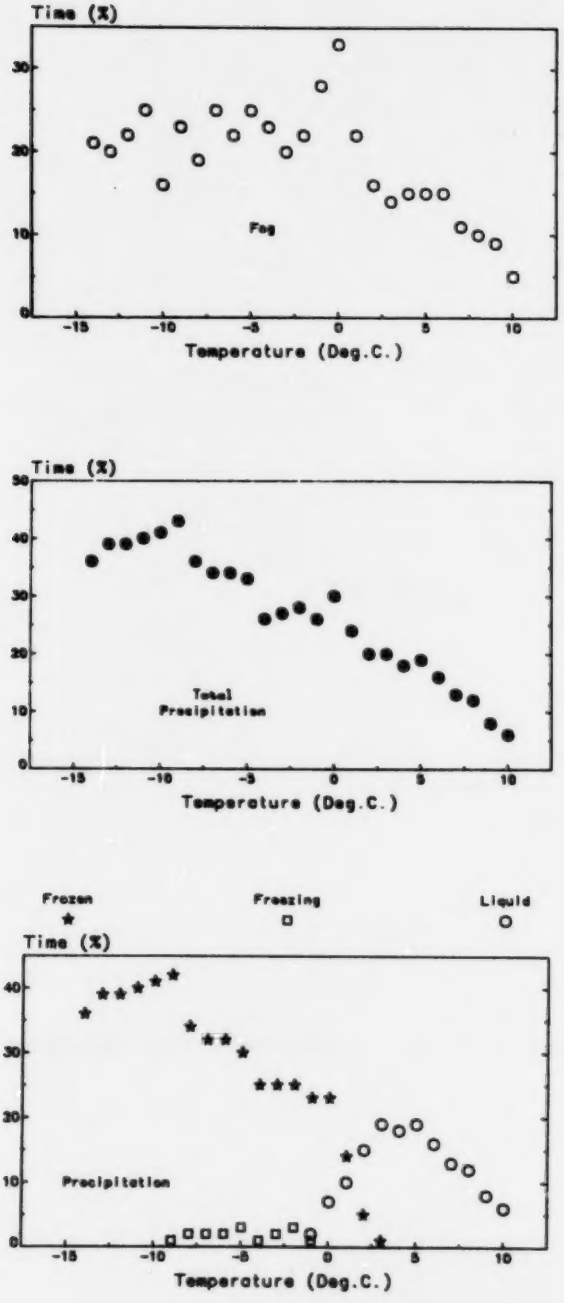



Figure A-11 (b) Fog and Precipitation for Cambridge Bay

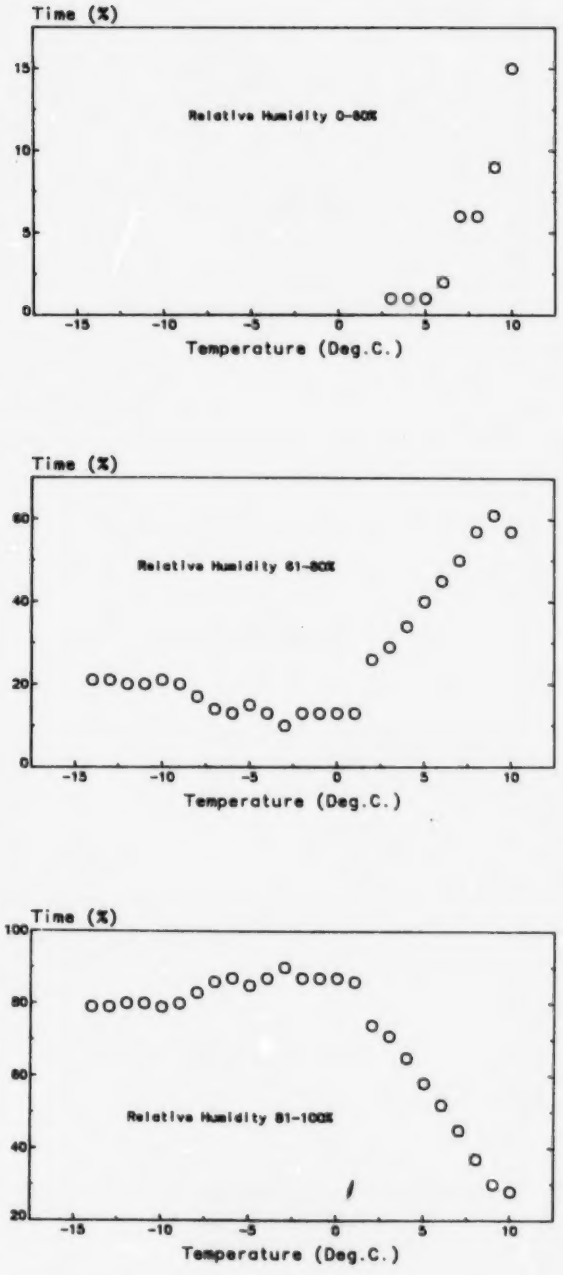



Figure A-11 (c) Relative Humidity for Cambridge Bay

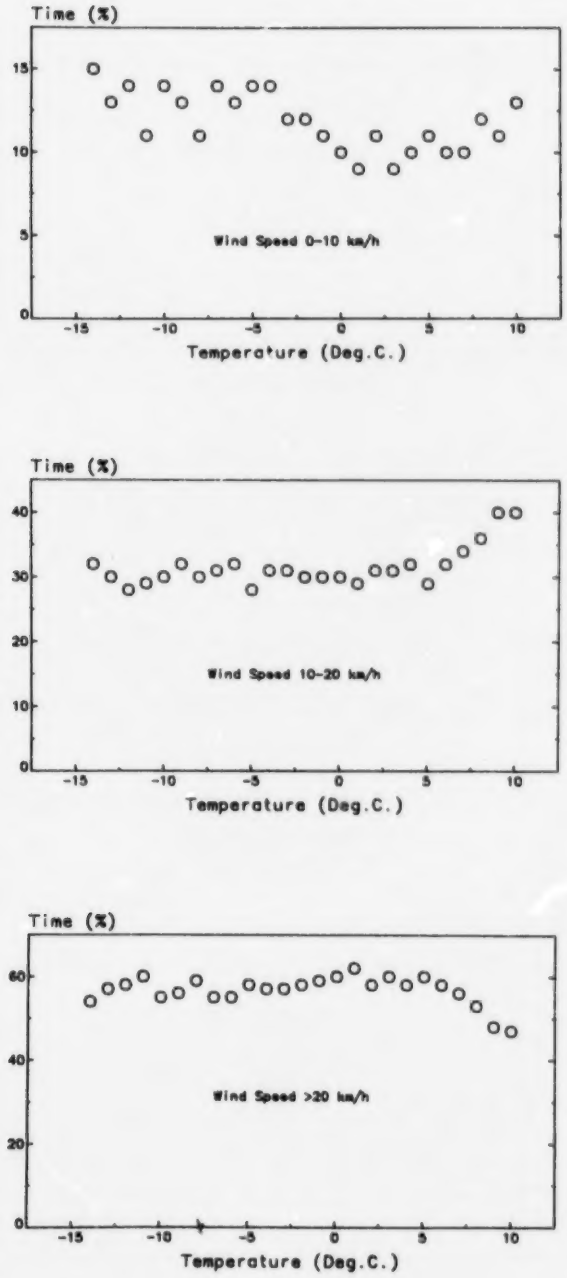
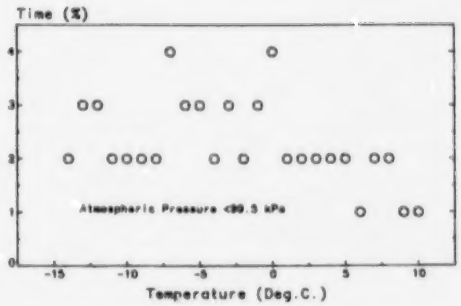
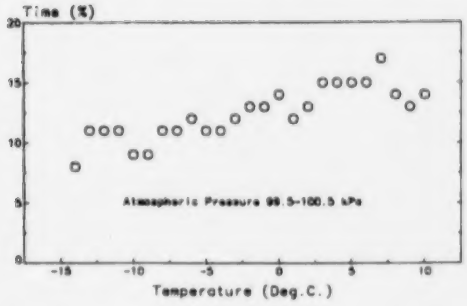
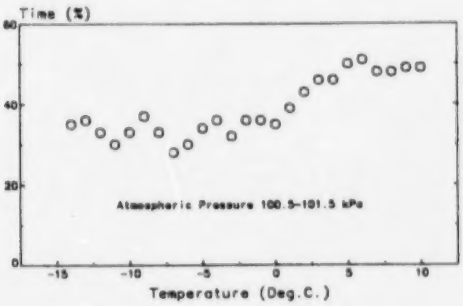
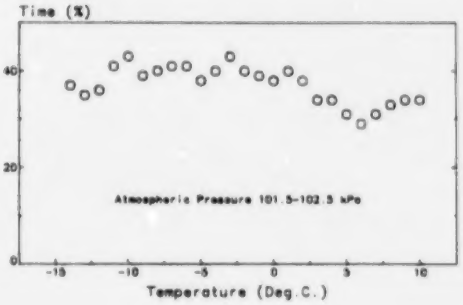



Figure A-11 (d) Wind Speed for Cambridge Bay



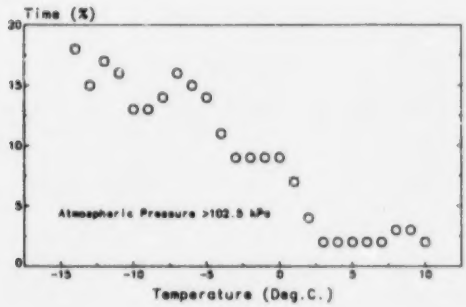




Figure A-11 (e) Atmospheric Pressure for Cambridge Bay

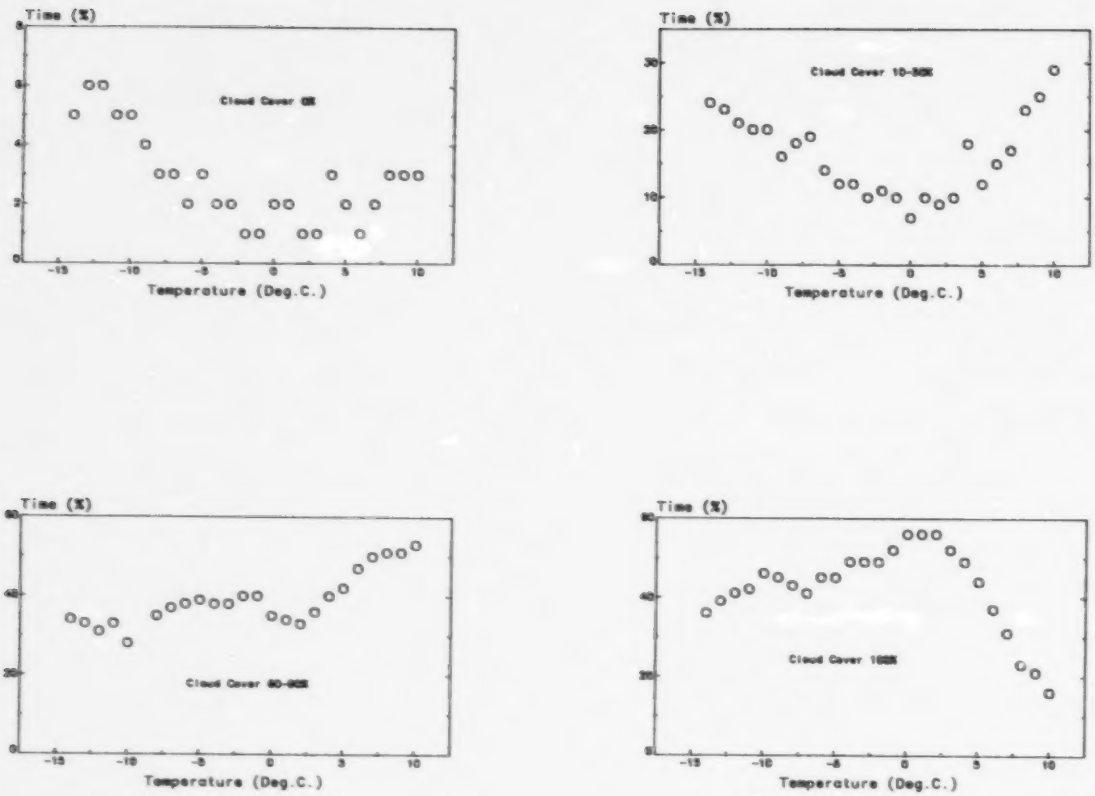



Figure A-12 (a) Cloud Cover for Iqualuit

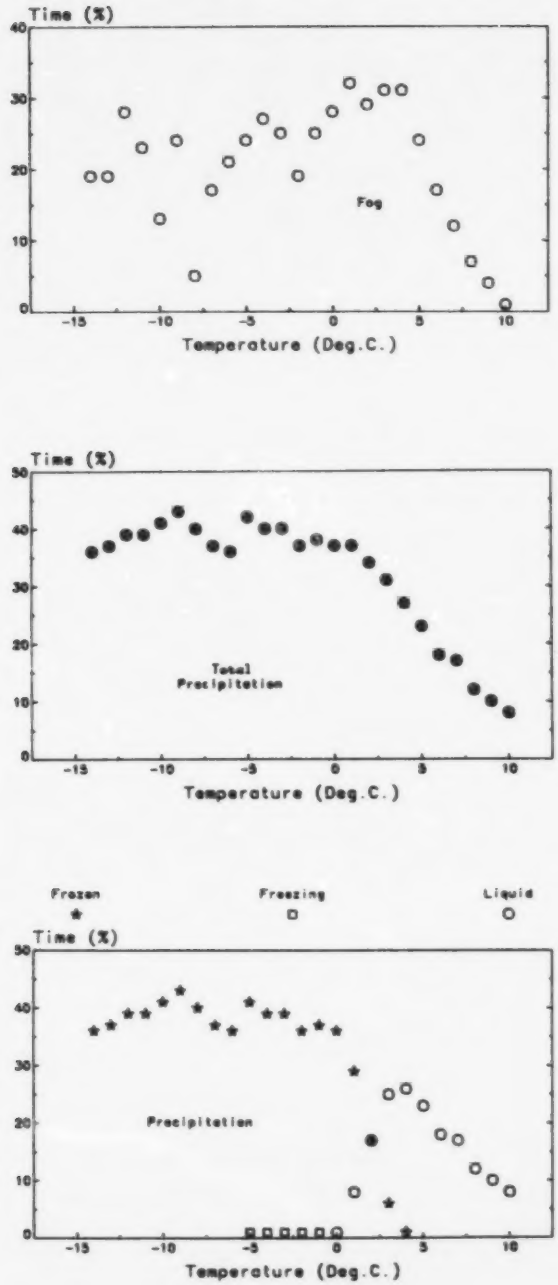
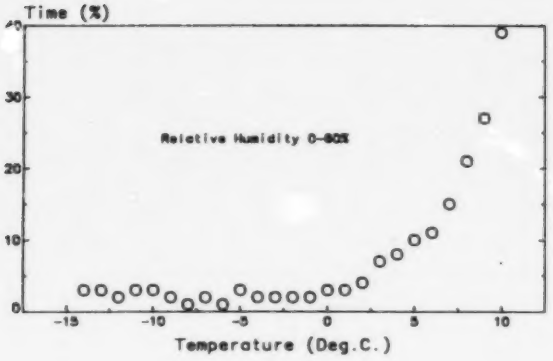
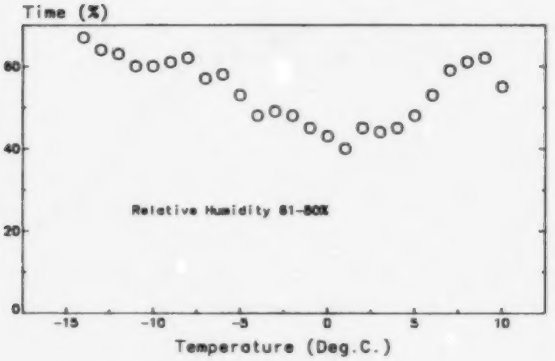



Figure A-12 (b) Fog and Precipitation for Iqualuit



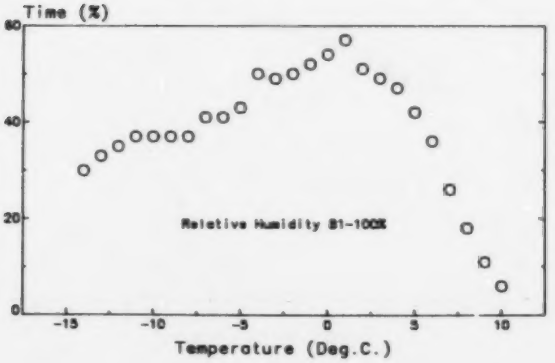




Figure A-12 (c) Relative Humidity for Iqualuit

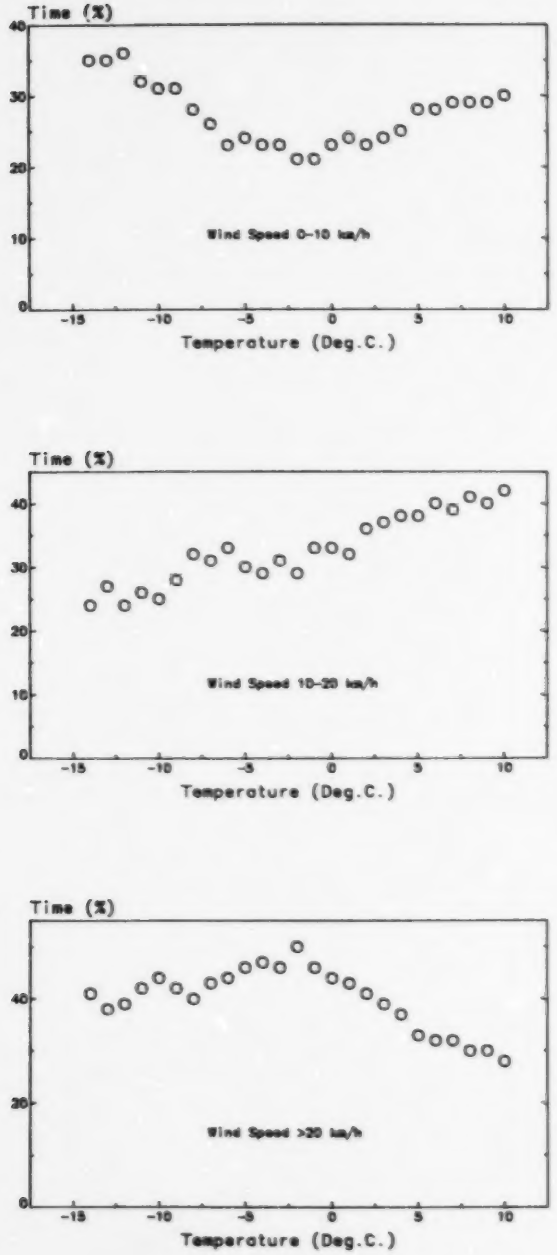



Figure A-12 (d) Wind Speed for Iqualuit

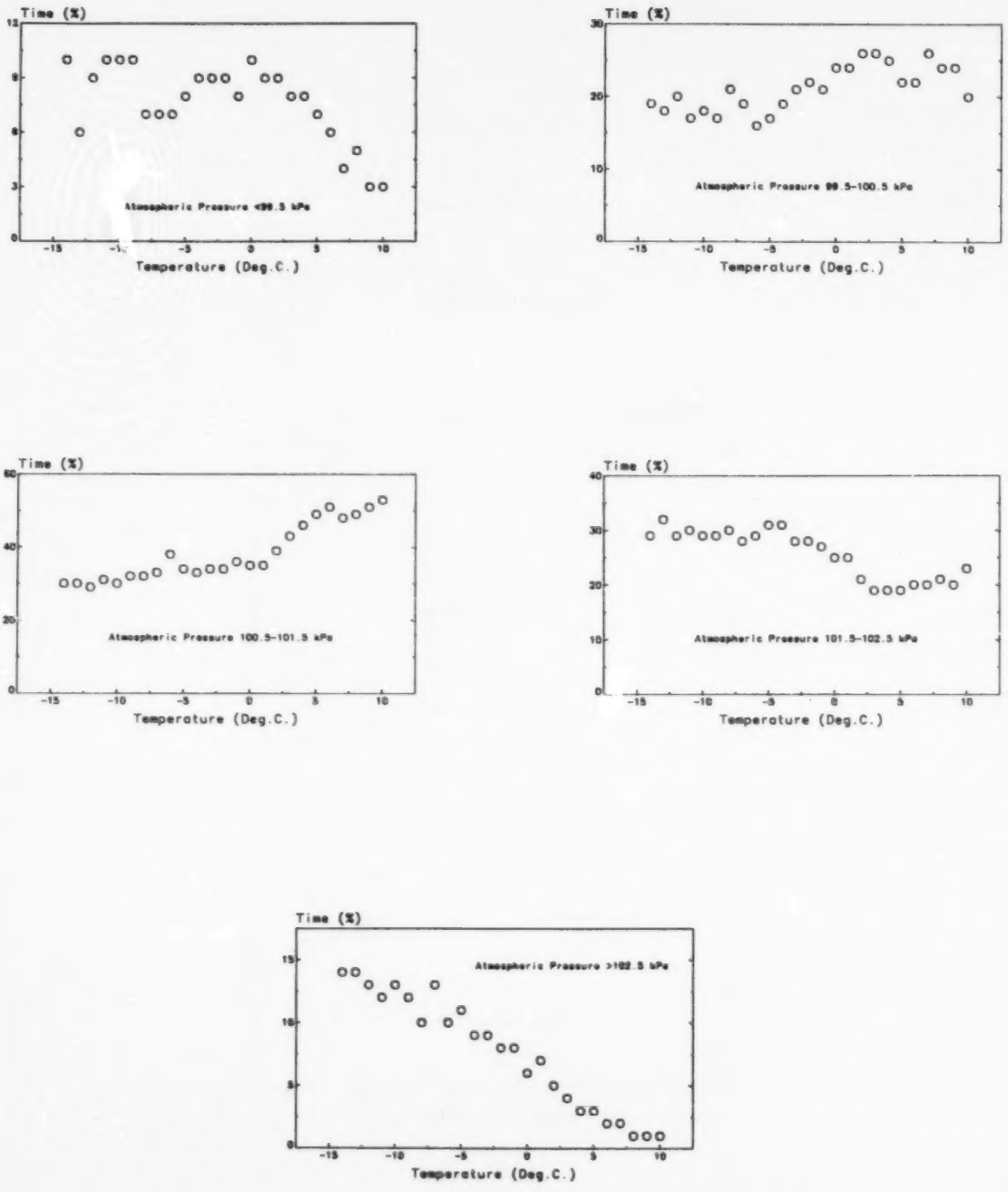



Figure A-12 (e) Atmospheric Pressure for Iqualuit

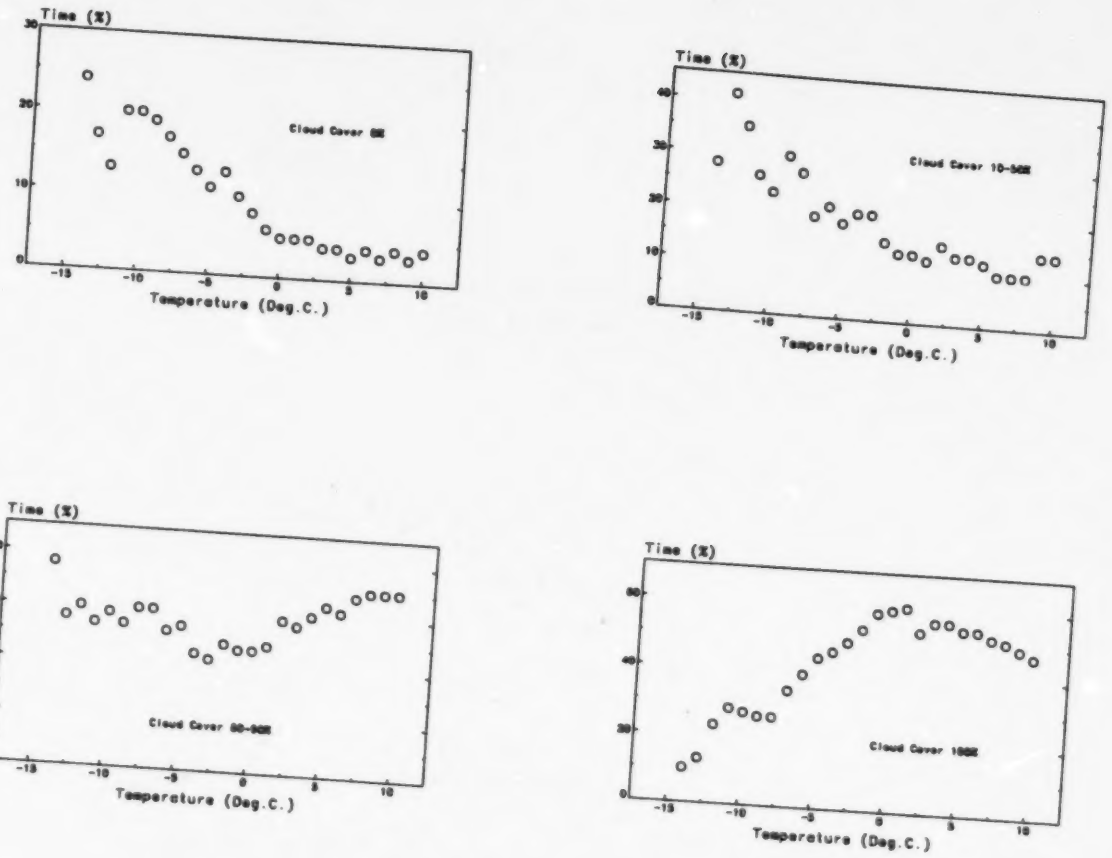
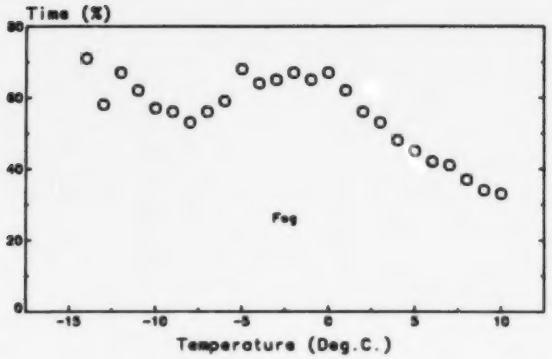
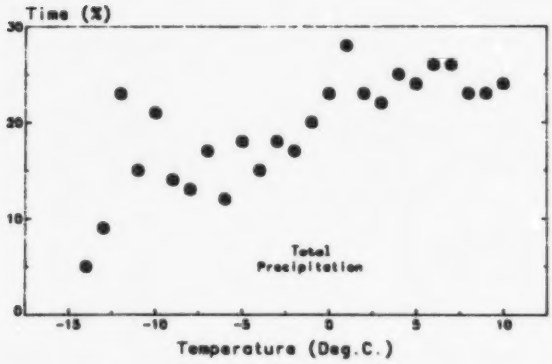



Figure A-13 (a) Cloud Cover for Baden-Soellingen



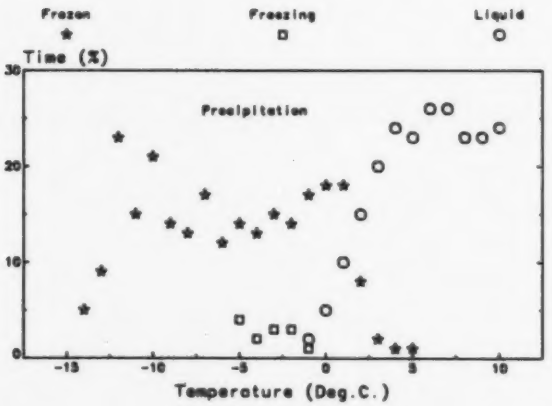
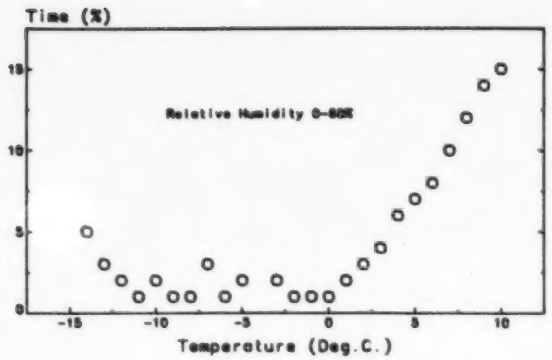
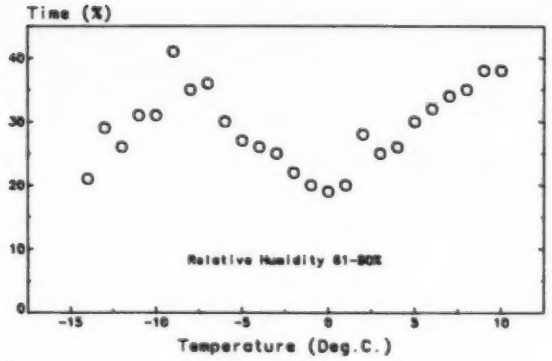




Figure A-13 (b) Fog and Precipitation for Baden-Soellingen



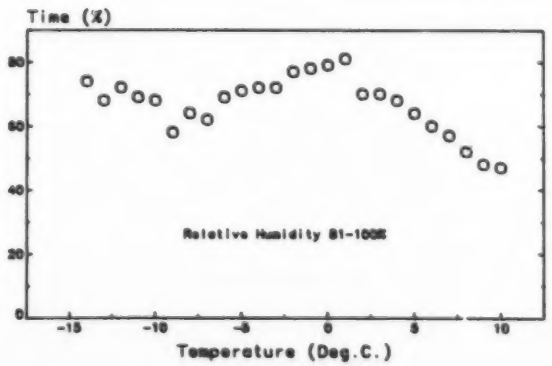
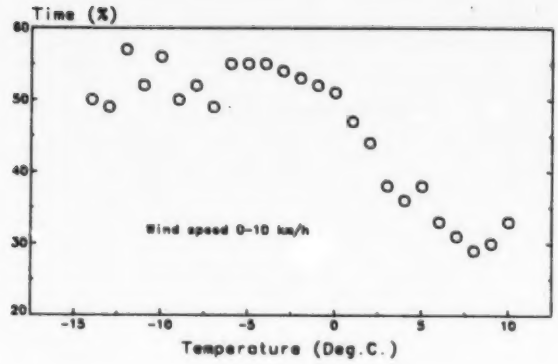
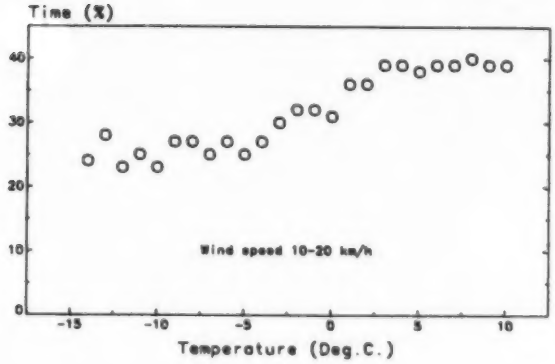




Figure A-13 (c) Relative Humidity for Baden-Soellingen



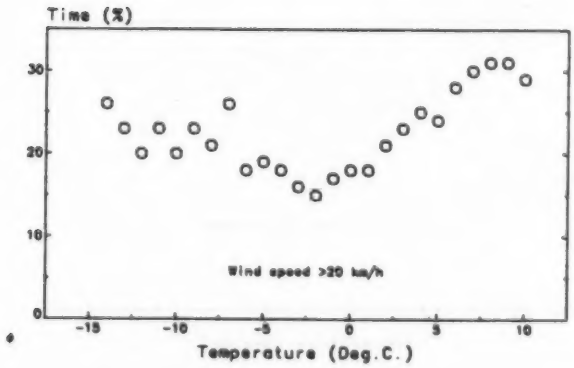




Figure A-13 (d) Wind Speed for Baden-Soellingen

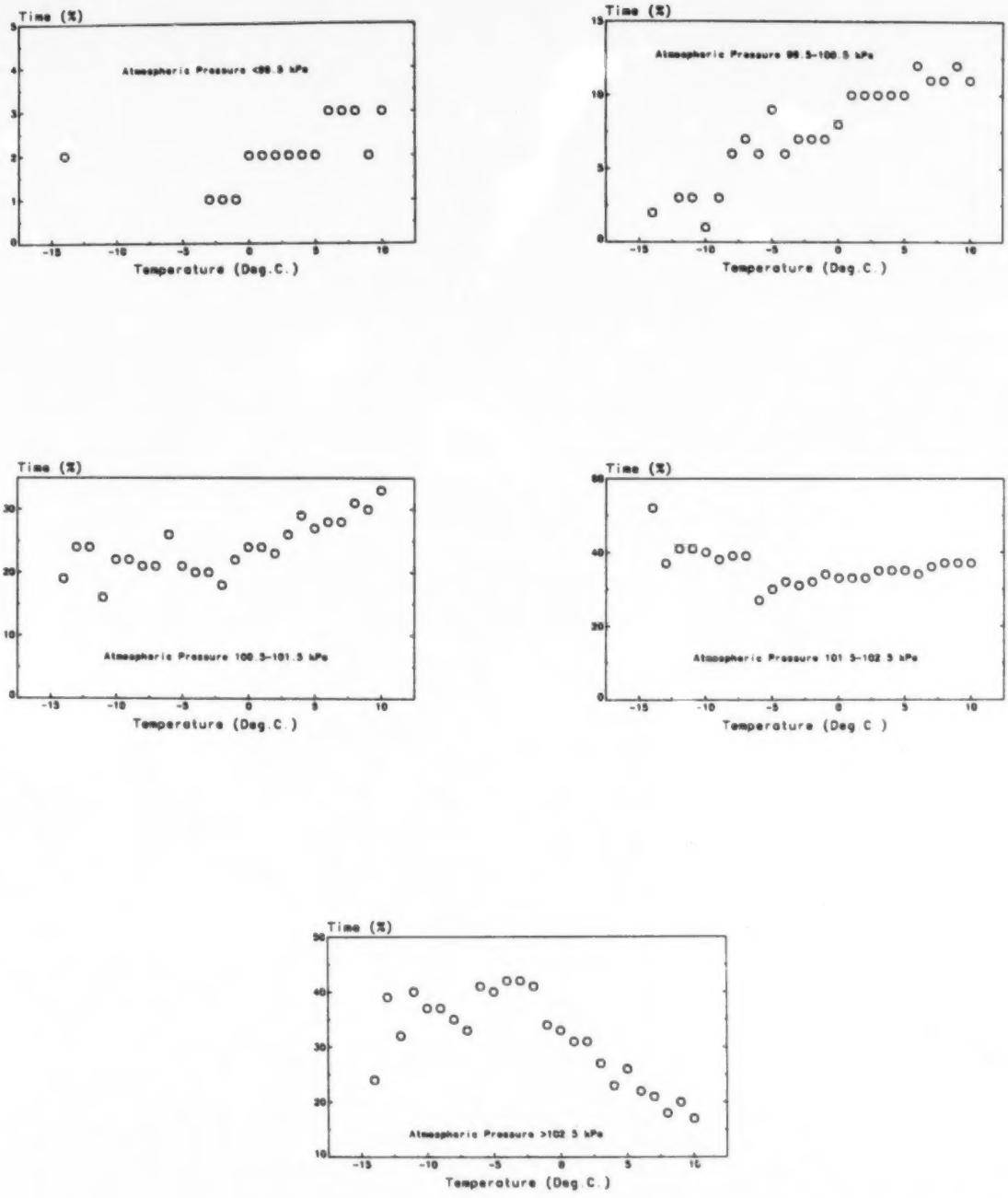



Figure A-13 (e) Atmospheric Pressure for Baden-Soellingen

## DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

DEFENCE RESEARCH ESTABLISHMENT OTTAWA
Department of National Defence
Ottawa, Ontario K1A 0Z4

2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable)

UNCLASSIFIED

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title.)

CHARACTERIZATION OF COLD-WET CONDITIONS (U)

4. AUTHORS (Last name, first name, middle initial)

CROW, Rita M. and DEWAR, Malcolm M.

5. DATE OF PUBLICATION (month and year of publication of document)

JUNE 1988

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

78

6b. NO. OF REFS (total cited in document)

2

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

TECHNICAL NOTE

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address.)

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

051LC

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)

10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DREO TECHNICAL NOTE NO. 88-23

10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; further distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM

13. ABSTRACT ( a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both offical languages unless the text is bilingual).

A study was done to determine if cold-wet could be characterized for 12 Canadian centres and Baden-Soellingen, Germany. It was found that, in general, the weather at about 0°C is cloudier and more humid. There is no correlation between temperature and wind or temperature and barometric pressure.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

METEOROLOGICAL DATA
SITES
CANADA, GERMANY
COLD-WET

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM